International Journal on Advances in Engineering Technology and Science
Volume: 2, Issue: 2, March-April 2016, e-ISSN: 2455-3131

Preparation and Characterization of Biodegradable Plastic Blend

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Abstract— **Plastics are widely used in packing and other industrial applications. The accumulation of plastic wastes in the environment creates many environmental problems. Thus development and use of biodegradable plastic was proposed as a solution for plastic waste problem. In this work, low-density polyethylene/linear low-density polyethylene/corn starch powder (LDPE/LLDPE/corn starch) films are prepared for obtaining of environment friendly biodegradable polymer. Master-batch of LLDPE and corn starch are prepared. Different quantities of master-batch are blended with LDPE. Different tests are performed to measure properties of film, these include tensile strength, elongation at break and density measurement of both the master batch with and without corn starch blend.**

Keywords— **Biodegradable Plastics, LDPE and Corn Starch, Biodegradation**

I. Introduction

Increasing concern exists today about the preservation of our ecological systems. Most of today's synthetic polymers are produced from petrochemicals and are not biodegradable. Persistent polymers generate significant sources of environmental pollution, harming wildlife when they are dispersed in nature. Biodegradable polymers can decompose into carbon dioxide, methane, water, inorganic compounds or biomass via microbial activities within the natural environment. Several biodegradable polymers are now in the market or at an advanced stage of development; starch-blends, poly (butylene succinate) (PBS), poly (lactic acid) (PLA), poly (hydroxybutyrate) (PHB), and poly (caprolactone) (PCL). The extent of biodegradation of individual polymers in the environment is an important factor in managing biodegradable polymer wastes. Aerobic composting as well as anaerobic digestion (e.g., landfill) is used for the final disposal of biodegradable polymer wastes. In addition to the biodegradability, the biodegradation rates of biodegradable polymers need to be evaluated when deciding suitable waste management methods and for designing future waste disposal facilities.

Biodegradation takes place through the action of enzymes and/or chemical deterioration associated with living organisms. This event occurs in two steps. The first one is the fragmentation of the polymers into lower molecular mass species by means of either abiotic reactions, i.e. oxidation, photo-degradation or hydrolysis, or biotic reactions, i.e. degradations by microorganisms. This is followed by bio assimilation of the polymer fragments by microorganisms and their mineralization. Biodegradability depends not only on the origin of the polymer but also on its chemical structure and the environmental degrading conditions. Mechanisms and estimation techniques of polymer biodegradation have been reviewed. The mechanical behavior of biodegradable materials depends on their chemical composition, the production, the storage and processing characteristics, the ageing and the application conditions.[1,2,3]

Partially biodegradable polymers obtained by blending biodegradable and non-biodegradable commercial polymers can effectively reduce the volume of plastic waste by partial degradation. They are more useful than completely biodegradable ones due to the economic advantages and superior properties, imparted by the commercial polymer used as a blending component.

Blends of low density polyethylene (LDPE) and linear low density polyethylene (LLDPE) have gained many attentions in film packaging applications. LDPE exhibits good processability and high melt strength due to its long chain branching. Conversely, LLDPE is well known for superior mechanical properties e.g. higher tensile strength, elongation at break and impact strength. Therefore, LDPE/LLDPE blends would provide processability and mechanical properties, simultaneously. Another advantage of LDPE/LLDPE blending is using the conventional LDPE film blowing apparatus without modification.

Among the polysaccharides, starch has generated renewed interest in its use as a component in plastic formulations. Starch is among the most commonly used bio-filler in polyethylene because of its abundant availability and low cost.

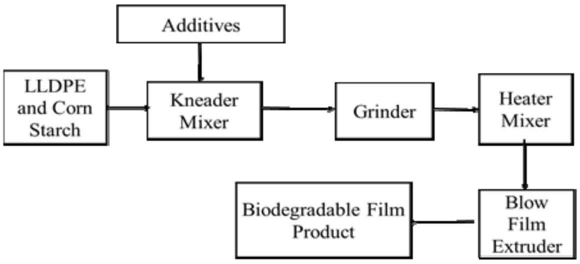
II. Bio-degradable Film Preparation

2.1 Master-batch preparation

2.1.1 Materials Required:

Material	Weight, kg
LLDPE (M26500)	4.00
Corn Starch powder	10.00
Calcium stearate (Filler)	10.00
Oleic Amide (Plastic T)	0.200
Zinc stearate	0.200
CaO	1.00
Elastomer (Vitamax 620)	1.00
I1010	0.010
Maleic anhydride	0.005
Paraffinic Oil	1.50

2.1.2 Procedure



Here biodegradable films were produced in by four operational zones:

1. Mixing
2. Grinding
3. Preheating and Mixing
4. Extrusion

Master-batches are prepared at "Agile product" at santej-ahmedabad. Master-batch of LLDPE (Density Linear Low Polyethylene) and corn starch powder are prepared in kneader mixer Shown below in figure 16. First LLDPE and corn starch powder are feed into kneader mixing chamber. Initial temperature of kneader mixer is 100-105 0C. After preheating of LLDPE and corn starch powder, additives are added at 115 0C. LLDPE, corn starch powder and additives are processing time are 1hr and 15 minutes. Final temperature of kneader mixer is 165-170 0C. All components are uniformly mixed by sigma blade containing in mixer chamber. Sigma blades are rotated by electric moter. Final mixtures are removed from mixing chamber collected in collecting pan. These mixtures are cutting into small pieces by knife. After cutting of these products are cooled by air fan. Final weight of master-batch is 26.800 kg.

Grinding:

Master-batch of LLDPE and Corn starch powder are grinded into grinder at "Ramdev Plastics" Ahmedabad shown in figure. Small pieces of master-batches are grinded into grinding machine. Master-batch was feed through hopper of grinder. These feed were cut into very small particles by knife which is attached to cylinder and rotated by moter. Grinding time of master-batch are 10 minutes. Finished products are collected at the bottom of the grinder.

Preheating and Mixing:

Low density polyethylene granules and grinded master-batch are heated and mixed into heater mixer. LDPE and grinded master-batch sample are heated and mixed upto 60 – 65 0C. For preparation of first sample preparation 85 wt% LDPE granules and 15 wt% grinded master-batch sample are heated and mixed. 0.5 kg of anti-moisture powder added into mixture. Operating time of heater mixer is 10 minutes. After 10 minute heated and mixed materials are removed by exit valve.

Blow Film Extruder:

Sample from heater mixer are feed through hopper and passed to screw barrel. Screw barrel have six heaters. Temperature profile along six heating zones of extruder barrel is 120 – 150 0C from feed zone to die and speed of screw was set at 150 rpm. The prepared blends were emerged in the form of continuous strands through the die. The exit temperate of blend at die was 160 0C. The melt is cooled before leaving the die to yield a weak semi-solid tube. This tube's diameter is rapidly expanded via air pressure, and the tube is drawn upwards with rollers, yielding the plastic in both the transverse and draw directions. As the film continues to cool, it is drawn through several sets of nip rollers to flatten it into lay-flat tubing, which can then be spooled or cut.

Here, two types of film produced in second trial 80 wt % of LDPE granules and 20 wt% grinded master-batches was added.

2.2 Testing

2.2.1 Tensile strength and Elongation at break

Tensile Strength at Break - The tensile strength at break shall be calculated in MN/m2 (kg/cm2) from the original area of cross section. The mean of five results shall be expressed for the lengthwise and cross wise samples.

Tensile Strength = Load at Break / ((Original width) * (Original Thickness))

Tensile strength of low density polyethylene film is 69 kg/cm2
Tensile strength of low density polyethylene film with 15% LLDPE and corn starch master-batch is 67 kg/cm2
Tensile strength of low density polyethylene film with 20% LLDPE and corn starch master-batch is 66 kg/cm2

Elongation at Break - Elongation at break shall be expressed at percentage of the original length between the reference lines. The mean of five results shall be expressed for the lengthwise and crosswise samples.

Elongation at Break = (Elongation at rupture * 100)/ Initial Gage Length

Elongation at break of LDPE film is 250%
Elongation at break of LDPE film with 15% LLDPE and corn starch master-batch is 226%
Elongation at break of LDPE film with 20% LLDPE and corn starch master-batch is 146%

2.2.2 Density Measurement

Density is a measure of the "compactness" of matter within a substance and is defined by the equation:

Density = mass/volume

The standard metric units in use for mass and volume respectively are grams and millimeters or cubic centimeters. Thus, density has the unit grams/millimeter (g/ml) or grams/cubic centimeters (g/cc).

Density of LDPE film is 0.920 gm/cc.
Density of LDPE film with 15% LLDPE and corn starch master-batch is 0.918 gm/cc.
Density of LDPE film with 20% LLDPE and corn starch master-batch is 0.915 gm/cc.

2.2.3 Moisture Content

The moisture content of the sample is calculated using the following equation:

%W = (Initial Weight – Oven Dry Weight)/Oven Dry Weight

Where %W = Percentage of moisture content.

Moisture content in corn starch powder is 1.28%
Moisture content in LLDPE and corn starch master-batch is 1.536%

Properties	LDPE film without master-batch	LDPE Film with 15% master-batch	LDPE Film with 20% master-batch
Tensile strength	69 kg/cm^2	67 kg/cm^2	66 kg/cm^2
Elongation at break	250%	226%	146%
Density	0.920 gm/cc	0.918 gm/cc	0.915/cc
Moisture% in corn starch powder = 1.28%			
Moisture% in LLDPE and corn starch powder = 1.53%			

III. COSTING

3.1 Costing of product with 15% master-batch

Kneader mixer

Material	Material used in kg	Cost/kg in Rs	Total cost of material in Rs
LLDPE	4.00	80	320
Corn Starch powder	10.00	25	250
Calcium stearate	10.00	94	940
Oleic Amide	10.200	132	26.4
Zinc stearate	0.200	90	18.00
CaO	1.00	4	4.00
Epdm (Vitamax 620)	1.00	150	150
I1010	0.010	200	2.00
Maleic hydride	0.005	70	0.35
Paraffinic Oil	1.501	150	150
Total	**27.915**		**1860.75**

Total cost of master-batch per kg after grinding = (Cost of master-batch in kneader mixer per kg + Energy consumed by grinder per kg in Rs) = (70.43 Rs/kg + 0.33 Rs/kg) = 70.79 Rs/kg

Heater Mixer

Material	Material used in kg	Cost/kg in Rs	Total cost/material in Rs
PRLD	7.00	75	525
RLD	1.50	65	97.50
PLD	1.00	70	70.00
Grinded master-batch	1.5	70.97	106.18
Anti-moisture powder	0.5	23	11.50
Total	**11.50**		**810.18**

Total cost of product with 15% master-batch = 70.99 + 13.04 = 84.03 Rs/kg

3.2 Costing of LDPE film without master-batch

Heater Mixer

Material	Material used in kg	Cost/kg in Rs	Total cost/material in Rs
PRLD	8.00	75	600.0
RLD	1.50	65	97.50
PLD	1.50	70	105.0
Anti-moisture powder	0.5	23	11.50
Total	**11.50**		**814.0**

Total cost of product without master-batch = 71.32 + 13.04 = 84.36 Rs/kg

3.3 Comparisons of cost of products per kg in Rs

Type of Product	Cost/kg of Product in Rs
Product with 15% master-batch	**84.03**
Product without master-batch	**84.36**

IV. CONCLUSION

The polymer blend so formed can be used to easily replace the commercial use of LLDPE, where slight changes in properties are appreciable. The cost of polymer blend is almost same as that of LLDPE thus omitting the myth that production of bio-polymers is expensive. Obviously, the increased biodegradability will help in rescuing the problems associated with pollution and environment considerations.

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