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Characterization of Banana Fiber Reinforced With PLA Composites and its Effect on ZnO Nanoparticle

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Abstract—*Packaging in general is classified into two significant types i.e. Rigid Packaging and Flexible Packaging. As compared to rigid packaging, flexible packaging is one of the most dynamic and fastest growing markets in India. Flexible packaging anticipates a strong growth in the future. There has been increasing shift from traditional rigid packaging to flexible packaging due to numerous advantages offered by flexible packaging such as convenience in handling and disposal, savings in transportation costs etc.*

Biodegradable *packaging are intended to reduce waste.* **Biodegradable** *is a type of material that can decompose into natural elements under the action of microorganisms within a short period of time after disposal – typically a year or less. There are special characteristics of biodegradable items which include:*

- *They consist of renewable resources*
- *Or they can be harvested directly from nature*
- *Therefore, they can completely decompose, with the aid of micro organisms, when placed in a composting area*

The aim of my work is to develop a hybrid bio composite from Poly Lactic acid (PLA) in which Natural Banana Fibers (BF) and Zinc Oxide Nanoparticles (ZnO NP) will be added to improve the properties of the bio-composite. The composition of BF and ZnO NP will be varied to study the effects of loading rate on the properties such as mechanical (impact test) and biodegradation test, rate of the bio-composite.

Keywords: *Natural fiber composites, banana fibers, polymer composites, poly(lactic acid) (PLA), biodegradable, zinc oxide, tensile test, antimicrobial test.*

1. Introduction

The current market value of biodegradable plastics exceeds $1.1 billion in 2018, but could reach $1.7 billion by 2023, the report says.

Biodegradable or compostable polymers are bio-based or fossil-fuel-based polymers (plastics) that undergo microbial decomposition to carbon dioxide and water in industrial or municipal compost facilities. A few of these polymers decompose in backyard compost bins or in soil, freshwater or saltwater.

The food packaging, disposable tableware (cups, plates, and cutlery) and bags sector is the largest end-use segment, as well as the major growth driver for biodegradable polymer consumption. This segment will benefit from local restrictions on plastic shopping bags and will achieve double-digit growth. Compost bags are the second most important end-use for biodegradable polymers. This market segment will experience strong growth thanks to the gradual expansion of composting infrastructure and growing interest in diverting organic waste such as leaves, grass clippings and food waste from landfill, according to the IHS Markit Chemical Economics Handbook: Biodegradable Polymers Report.

2. Experimental Methods

2.1 Materials

Base matrix: PLA obtained from Amazon.in | India's Largest Online Store, was used as 1.75mm PLA Plus Transparent Filament. The MFI for PLA is between 1 and 2 g/10 min (190^0C, 2.19 kg).

Figure 1. PLA

Reinforcement materials: Banana fibers obtained from GO GREEN PRODUCTS, Gandhi Road, Chennai, Tamil Nadu. The density of banana fiber used 1.35g/cm^3 as reinforcement.

Figure 2. Banana Fiber

Nanostructure material**:** Zinc oxide(zno) powder obtained from Thermo Fisher Scientific India Pvt Ltd , Powai, Mumbai.

Cardanol liquid: To used for reduce its brittleness property.

NaOH and Acitic Acid: To used for chemically treatment (Banana Fiber).

2.2 Methods

Banana Fiber Alkali Treatment

Surface Treatments: Banana fiber, in the form of bundles, They were cut into a length of 13–15 cm, and scoured in Mild detergent solution at 60°C for a 2 hrs. to remove dust and other impurities. Finally, the fibers were washed into distilled water and dried in air for 2 days to remove moisture and other volatiles for better results.

Figure 3. Banana fiber after surface treatment

Mercerization or NaoH Treatment: Treatment of the fibers were carried out by immersing the fibers in 1N Sodium hydroxide (NaoH) solution for 1 hrs. at room temperature. Then, the fibers were washed with distilled Water and containing few drops of acetic acid(CH_3COOH), followed by through the washing under continuous stream of water until The complete removal of NaoH residue. Subsequently, the mercerized fibers were dried at room temperature for 24 hrs. and then in a vacuum oven at 80°C for 12 hrs

Figure 4. Desiccation process of Banana fiber

PLA Treatment

PLA obtained from 3D filament use as wire form and after that it was cut into granule form, from trim cutter machine.

2.3 Composite Preparations:

Zone 1: T=180°C ; Zone 2: T=190°C; Zone 3: T=200°C

Zone 4: T=210°C ; Zone 5: T=220°C. Blending Speed – 42 RPM

Figure 5. Control Panel of Twin Screw Extruder

- To improve the dispersion of Zno/Cardanol in PLA/BF a masterbatch with composition PLA/BF/zno/Cardanol V/88/74/60 was prepared by mixing of the components by using a twin-screw extruder, Collin ZK25.The masterbatch was diluted in PLA to obtain the desired composition.

Table 1: Composition of Composites

S.No	PLA(weight%)	BANANA FIBER(weight%)	ZnO (weight %)	CARDANOL(weight%)
1	100	0	0	0
2	88	10	1	1
3	74	20	3	3
4	60	30	5	5

2.4 Preparation Of Specimen

Tech. Used – Compression molding

Figure 6. Compression moulding machine

Processing parameter
- Prepressed time : 15 sec
- Temp. : 200°C
- Pressure : 400 Pa
- Time : 5 min
- Thickness of sheet : 3 mm

Figure 6. Sample (100:0:0:0)

Figure 7. Sample (88:10:1:1)

Figure 8. Sample (74:20:3:3)

Figure 9. Sample (60:30:5:5)

3. Testing

3.1 Impact Properties

Izod impact strength testing is an ASTM standard method (ASTM-D256), of determining impact strength. A notched sample is generally used to determine impact strength. The impact properties of the polymeric materials depend mainly on the toughness of the material. Toughness can be described as the ability of the polymer to absorb applied energy. The molecular flexibility has a great significance in determining the relative brittleness of the material. Impact energy is a measure of toughness, and the impact resistance is the ability of a material to resist breaking (fracture) under a shock loading. An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined.

Test Procedures and measurements:

Specimens of dimension 63.5 x 12.7 x 3 mm. were taken for measurement of impact test in an Impactometer (M/s Ceast, Italy) as per ASTM D 256. The specimens were notched at angle of 45° and depth of 2.54mm using notch cutter (M/s Ceast, Italy) prior to test.

Two basically different test methods, namely Izod type and Charpy type, are used generally. Present study utilize the Izod type impact testing. In Izod type testing, the specimen is clamped vertically to a cantilever beam and the pendulum arm swung from certain height is made to impact on a notched cantilevered specimen. The loss of energy is measured in ft-lb/in or J/m or kg-cm/c m of specimen thickness, is known as Izod impact strength. The Izod impact test differs from the Charpy impact Test in that the sample is held in a cantilevered beam configuration as opposed to a three point bending configuration.

Factors affecting the Impact Strength:

- The rate of loading has a significant effect on the behavior of the polymer during testing. At high rates of impact, even rubber-like materials may exhibit brittle failure.
- All plastics are notch-sensitive. A notch or a sharp corner in a fabricated part creates a localized stress concentration, therefore, both the notch depth and notch radius have an effect on the impact behavior. Larger radius will have a lower stress concentration, resulting in higher impact energy of the base material.

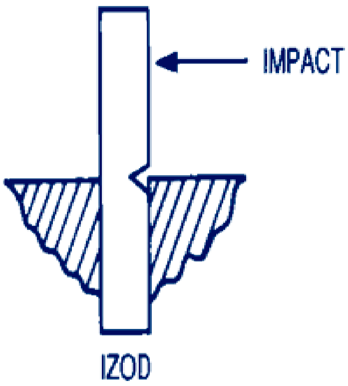


Figure 10 Specimen hold position

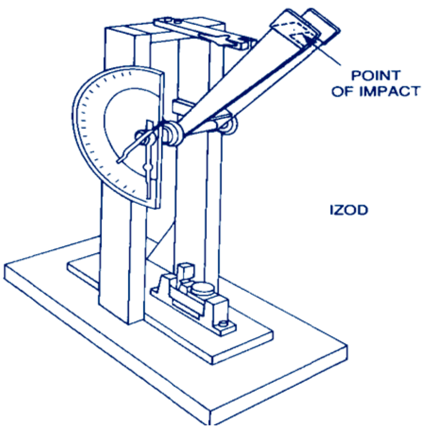


Figure 11. Izod Impact meter

3.2 Biodegradation Test:

A number of researchers and research groups have already identified the possibilities for completly biodegradable biocomposite products through combining biodegradable polymers with natural fiber reinforcement. The chemicals used for surface modification of fiber may affect the biodegradability of biocomposites. In present study it was observed the effect of chemicals on the biodegradability on resulting composites. Several studies on PLA and its composites have focused by means of only enzymatic or hydrolytic degradation and only few study of microbial degradation has been reported. In our study biocomposites was subjected for bacterial and fungal degradation.

Preparation of Basal culture medium (Potato Dextrose Agar)

Figure 12.

Preparation of PDA 3.6 gm (2-4%) potato dextrose broth was dissolved to the 150 ml of distill water in a conical flask and mixed 2.7 gm (1.8%) of Agar-Agar. mixed well by shaking. Finally the solution was heated up to clear solution. It should be noted that conical flask should be doubled to the media volume to avoid contamination.

Sterilization of media and glass ware

Sterilization was performed by the autoclaving of both media and glassware at 121 ^{o} C for 20 min. at 15 lb/inch2.All of required glassware were wrapped in to the paper and put inside the autoclave.

Sample collection

Soil sample was collected from sewage in the sterilized bottle with sterilized spatula from which 1 gm of sample was weighted and put in to the laminar air flow.

Culture conditions

All culture media were incubated at 30 ^{o}C. Liquid media were shaken under gentle rotation at 150 rpm for 7 days. In all cases, controls without inoculation were used.

Serial dilution

Six sterilized vial were taken and marked as 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6}. 1 gm soil sample was added to 10 ml distilled water in first vial marked as 10^{-1}. 1 ml solution from the vial 10^{-1} is transferred to a vial (B) marked as 10^{-2} having 9 ml of distill water. Like was dilution was made up to 10^{-6} total 6 sample solutions.

Spreading

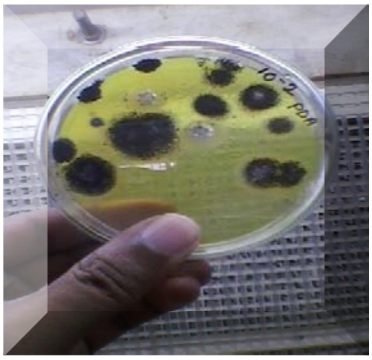
0.1 ml of sample was taken from vial and transferred to conical flask containing media marked as 10^{-1}.Similarly 0.1 sample from $10^{-2,}$ 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} and transferred to conical flask marked as $10^{-2,}$ 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} respectively.

Incubation

Incubation is done by keeping the solution for 7 days at temperature 22±2 °C and 50±0.2 mm Hg relative humidity.

Inoculation

Inoculation with the fungal strain was accomplished with a spore suspension obtained from a potato dextrose agar culture after 7 days of incubation at 22 °C.



Inoculation

Fungal growth

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