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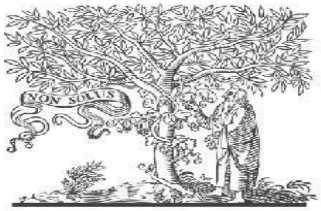

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Paper Authors
Dr. Kedar Mallik, P.Swami, P.Madhu sudhan, S.Ranadev, T.Abhilash

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Fabrication and Analysis of Recycled PLA wire blended with Bakelite

Dr. Kedar Mallik, M.Tech,Ph.D, Department of MECH,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.

P.Swami, **P.Madhu sudhan**, **S.Ranadev**, **T.Abhilash**
UG Students, Department of MECH,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.
E-Mail ID: Mallikkedar@vvit.net

Abstract

Phenol-formaldehyde resin, commonly known as Bakelite (C16H26O2), is a thermosetting plastic that can be quickly molded into a wide range of vibrant colors. It becomes pliable and liquefiable when heated, but once cooled, it becomes rigid and retains its shape permanently. Bakelite is widely used in the production of non-conducting components of electrical devices such as sockets, wire insulation, switches, and automobile devices. On the other hand, PLA (polylactic acid) is a monomer that is derived from renewable organic sources like corn and starch. Unlike most plastics, which are produced using fossil fuels, PLA production involves distilling and polymerizing petroleum. The aim of this project is to blend PLA with Bakelite using different procedures and create a wire.

1. Introduction

Introduction for material:

- Material A used in this procedure is the BAKELITE. Chemically Bakelite is termed as Phenol formaldehyde resin (C16H26O2).
- Material B is PLA (POLYLACTIC ACID) in the form of a wire which is the most important material in 3D printing applications.
- The main reason to choose Bakelite as material A in this procedure is to analyze its properties of thermosetting to blend with thermoplastic.
- Also, Bakelite possesses some important properties such as being quickly molded, having heat resistance up to 120° on continuous operation, heat capacity of up to 0.92KJ/kg K, and being a thermosetting polymer Bakelite has a high strength to retain its form even after extensive molding.
- PLA is the basic material that is commonly used in 3D FDM or FFF printing application.

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Fig 1: Bakelite granules

- PLA is expensive and eco-friendlier with no fumes.

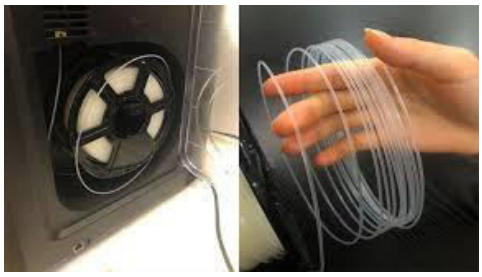

Fig 2: PLA wire

Bakelite Properties

- The polymer is cross linked
- It is light weight, strong, and rigid
- It is moldable
- It cannot be re-melted
- It exhibits high resistance to electricity and chemical action.

PLA Properties

Properties	Values
Density	1.24 g/cm^3
Tensile strength	60 MPa
Flexural strength	108 MPa
Elongation	9%
Young's modulus	3100 MPa
Shore hardness, *D*	85 Sh D
Melting temperature	145–160 °C
Glass transition temperature	56–64 °C

HEAT TREATMENT:

Heat treatment, also known as heat treating, encompasses a range of industrial, thermal, and metalworking processes utilized to modify the physical and, at times, chemical properties of a material. The most prevalent use of heat treatment involves subjecting a material to either high or low temperatures to achieve the desired result, which may include hardening or softening of the material.

Fig 3: Process of Heat treatment

Wire draw:

Drawing dies are typically made of tool steel, tungsten carbide, and diamond, with tungsten carbide and manufactured diamond being the most common. For drawing very fine wire, a single crystal diamond die is used. For hot drawing, cast steel dies are used. For steel wire drawing, a tungsten carbide die is used. The strength-enhancing effect of wire drawing can be substantial. The highest strengths available on any steel were recorded on the small-diameter cold-drawn austenitic stainless wire drawing,

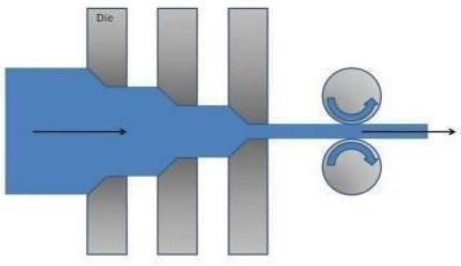

Fig 4: 2-D view of wire drawing

To prepare the wire, its starting end is shrunk by hammering, filing, rolling, or swaging to make it fit through the die. Afterward, the wire is pulled through the die.

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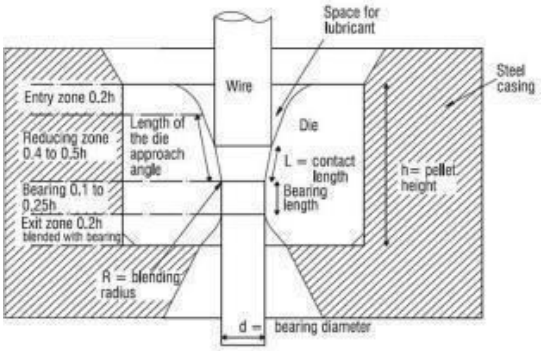
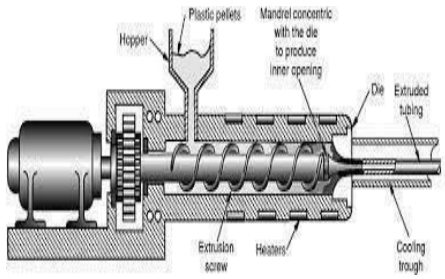


Injection moulding

Phenolic injection molding has been utilized in the industry for nearly 40 years. While it differs from conventional thermoplastic equipment, the process is quite similar. Although a special screw and a jacketed barrel are required, the basic concept of phenolic injection molding is similar to thermoplastic injection molding. With the appropriate modifications to the screw and barrel, the same machine can be used for both processes.



Procedure:

- The procedure is done with different equipment s as described below
- This is because to get a fine wire that can be used easily for our analysis
- And also being Bakelite is a thermos setting polymer and PLA is thermos plastic we want to confirm which method is better suitable.

Procedure1:

BLENDING OF BAKELITE AND PLA IN A OPEN FIREPLACE FURNACE

Fig-6: OPEN FIREPLACE FURNACE

Initially, we have taken 200gms of Bakelite Powder (approx.80%) and 50gms of PLA (approx.20%) and started the procedure. As a result, Bakelite didn't get change its state and settled stable and PLA stayed as wire and mixed with Bakelite solid form.

For a second time, we changed the composition of Bakelite to 150gms (approx.60%) and PLA to 100gms (approx.40%) and began the same process with some more added heat resistance as shown. As a result, Bakelite turned into a solid form and PLA completely melted.

The final step includes the equal composition of both Bakelite and PLA as 100 grams (approx. 50%) each.

Bakelite turns out to be a rigid solid form and got mixed with PLA wire. The obtained outcome cannot be utilized as a result.

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Fig-7: result after the procedure

Procedure2:

BLENDING OF BAKELITE POWDER AND ABS IN A MUFFLE FURNACE

The change of equipment gives a little progress and the initial composition is 150gms of Bakelite (approx. 80%) and 50gms of PLA (approx. 20%). As a result, Bakelite turned out too solid and mixed with PLA granules at the following three temperatures: 250deg C, 350deg C, and 400deg C in the machine.

The following step includes the composition of 100 grams of Bakelite (approx. 50%) and 100 grams of PLA (approx. 50%).

The obtained outcome of the above composition is ABS got mixed with Bakelite and Bakelite turned into a solid.

Coming to the final step, 50gms of Bakelite (approx. 20%) and 150gms of PLA (approx. 80%) got heat treated at the above- mentioned three temperatures, and obtained outcome doesn't suitable for wire drawing.

Procedure 3:
INJECTION MOULDING

Fig 8: Injection molding machine

The fundamental principle of phenolic injection molding is akin to that of thermoplastic injection molding, and with the necessary adaptations to the screw and barrel, the same basic machine can be utilized.

Here, the initial composition of 150gms of Bakelite and 50gms of PLA wire is injected into the barrel of the injection molding machine.

Observing the outcome, the material was not coming out of the nozzle. It just deposited inside the barrel.

The second step in the above procedure includes a similar composition of both PLA and Bakelite and is added to the machine as shown in fig 8.

As a result, materials slightly came out of the nozzle but doesn't form a continuous wire suitable for the further procedure.

Coming to the last step of the procedure, 25 grams of Bakelite and 175 grams of PLA were introduced into the machine.

A fine wire of PLA and Bakelite composition is drawn with a diameter of approximately.2mm.

Problem Statement: Objectives

- Prepare a wire using Bakelite and PLA.
- To identify the best combination which is suitable for 3-D printing.
- To fabricate and analyze the 3D printed components using Bakelite as a wire along with ABS.
- To conclude the properties exhibited by the components and to compare them with the standard ones.

Outcomes

- Bakelite is relatively inflexible and rigid when compared to the majority of 3D printed materials; it is more akin to hard acrylic resins or amber.
- Even though PLA is a good thermoplastic when it is blended with the Bakelite in small

composition it cannot give its plasticity properties it just evaporates or burns into charcoal.

- To conclude the Bakelite cannot change its nature when it is heated in any type of equipment while it is in raw form
- Coming to the end formation of wire with PLA it is very hard to blend PLA in small composition but in large amounts of PLA we can blend it with Bakelite and obtain a wire with the required diameter
- In this experimentation we got wire of 4 mm diameter wire through injection molding

Limitations

- Melting of raw Bakelite powder is impossible directly instead of adding a few additives for the melting procedure.
- To gainsuitable composition of Bakelite and PLA, the percentage of PLA should be more than compared to Bakelite.
- Melted Bakelite mixture should be inserted immediately into the machine

unless it will turn out into a hard solid form.

Future Scope

If the procedure is up to the mark, it reduces the cost of usage of abs percentage. Also, Bakelite is a thermoplastic material, the outcome product contains maximum stability to withstand higher loads and temperatures.

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