

Influence of Ammonium Polyphosphate on the Flame Retardancy and Mechanical Properties of Coconut Shell Powder-Reinforced PLA

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Abstract— Fully biodegradable natural fiber/biodegradable polymer composites have drawn a most of interest from researchers and have a number of uses, including components for but their use is restricted by their flammability. It's important to use environmentally sound flame retardants to increase the flame resistance of completely degradable composites. The physical properties under investigation of The great toughness, bulkiness, low heat conductivity, ability to insulate sound and heat, antistatic qualities, and other characteristics of coconut shell powder make it unique. Due to these properties, coconut shell powder is most appropriate for application in the production of composite materials under specific conditions. The flame-retardant properties of powdered coconut shell were investigated. For the purpose of making the experimental panels, ammonium polyphosphate, which was mixed with coconut shell powder, was reviewed as a flame retardant chemical. For the purpose of making the experimental panels, four fire retardant focusses (0, 1, 2, and 3%) and 20% coconut shell powder were mixed with resin. Both impact and tensile testing were carried out mechanically. Ammonium polyphosphate was shown to reduce PLA's tensile and impact strengths while increasing the amount of flame retardant. The fire retardant was improved

maximum than with less concentrations of ammonium polyphosphate.

Keywords- Coconut Shell Powder, Tenacity, ammonium polyphosphate, Flame Retardance

I- INTRODUCTION

A "composite" is a mixture of two materials, one of which is embedded in the other, known as the matrix phase, and is referred to as the reinforcing phase. The objective is to optimize the benefits of both materials' outstanding attributes without compromising their respective drawbacks. Composites are compound materials that differ from alloys in that individual components inside the composites maintain their properties while being integrated into the material in a way that only benefits from their positive features and not from their bad ones. The two types of composite materials are matrix and reinforcement. [1] The matrix material surrounds and supports the reinforcing components, holding them in place in relation to one another. The matrix's distinct mechanical and physical properties come from the reinforcements. Particles or fibres are the most common forms of reinforcement. The production of

coconuts ranks second in India. Coconut shell powder has some unique physical properties, such as its high toughness, bulkiness, low thermal conductivity, ability to withstand heat and sound, and antistatic qualities, among others. [2, 4]. Because of these qualities, coconut shell powder is better suited for some specific uses, like the creation of composite materials. Fillers are frequently referred to as extenders. Burning polymeric materials, such as cotton, wood, and paper-based items, does not create flammable vapours when exposed to boric acid.

Ammonium polyphosphate functions as a fire retardant in a variety of ways, such as by encouraging the production of char, inhibiting smoke, glowing, and smouldering flames, and blocking flame combustion. Ammonium polyphosphate is a non-alkaline borate that reacts to inhibit burning as well as retard fires. Ammonium polyphosphate contributes to the extinguishment of the fire by releasing water as well, however because of its boron content, it also forms char on the cellulose's surface. A flame was used to light each sample, which burnt into the unheated substance underneath. The lowest oxygen concentrations needed to sustain combustion for each sample were then calculated as a percentage [8]. It is widely accepted that ammonium polyphosphate works as a fire retardant through a physical mechanism that involves the creation of a protective layer or coating on the surface at high temperatures.

II -METHODOLOGY

The material that covers the reinforcement is chosen as the matrix when choosing constituents of a composite material. PLA are thermoset polymers, which means that their production pressure needs are low, their cure shrinkage is small, and their residual stresses are minimal. They can be used in a wide temperature range to change the degree of cross-links provided the right curing agent is selected.

PLA is available for distribution in the market as low-viscosity liquids and as powders, or solids. [5] Particles or fibres are the most common forms of reinforcement. The physical properties of coconut shell powder are unique and include great toughness, bulkiness, and low thermal conductivity, ability to insulate heat and sound, and antistatic properties, among others. Because of these qualities, coconut shell powder is more suited for the production of composites in some specific industries. The tensile strength will be significantly increased by the use of coconut shell powder. Extenders are a common term used to describe fillers. Burning polymeric materials, such

as cotton, wood, and paper-based products, inhibits the emission of flammable gases by containing coconut shell powder. [6, 8]

At comparatively low temperatures, ammonium polyphosphate catalyses the dehydration and other oxygen-eliminating processes of composite. The water breaks down more quickly because to dehydration catalysis, which accelerates the drop in temperature.

- Put the mould together and evenly apply the silicone mould release agent.
- After adding filler and allowing it to become consistent, pour the PLA mix into the mould.
- After that, incorporate the fibres into the mixture well.
- Press with 80 pressure while the top plate is positioned on the mould.
- After that, give it five hours to settle at room temperature.



Fig.1 Sample1 (80 PLA -20 coconut shell powder- 0 Ammonium polyphosphate)



Fig.2 Sample (79 PLA -20 coconut shell powder - 1 Ammonium polyphosphate)

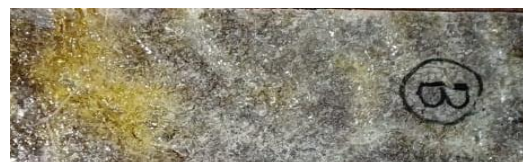


Fig.3 Sample (78 PLA - 20 coconut shell powder - 2 Ammonium polyphosphate)



Fig.4 Sample (77 PLA - 20 coconut shell powder - 3 Ammonium polyphosphate)

III -RESULT AND DISCUSSION

1. Tensile Test

Resin is a component found in many everyday items. Plastics are lightweight and strong materials that are just now starting to be used as structural components in vehicles such as cars and aero planes. It is essential to comprehend the mechanical strength properties of these plastics for a variety of applications. Procedures for determining the mechanical properties of resin-based materials, such plastics, are outlined in the ASTM D638 standard, along with precise requirements for the test frames and accessories used. Comparable JIS and ISO standards, JIS K 7161 and ISO 527, and ASTM D638 are not the same as each other. For additional information about ISO 527 and JIS K 7161 [11].

When the amount of ammonium polyphosphate is increased in relation to PLA and coconut shell powder, the tensile strength increases as well.

Table 1- Ammonium polyphosphate tensile test analysis results

Sr.No.	Sample	Tensile Strength
1	(80 PLA -20 coconut shell powder-0 Ammonium polyphosphate)	46.1
2	(79 PLA -20 coconut shell powder -1 Ammonium polyphosphate)	53.4
3	(78 PLA - 20 coconut shell powder - 2 Ammonium polyphosphate)	51.6
4	(77 PLA- 20 coconut shell powder - 3 Ammonium polyphosphate)	56.3

2. Impact Test

Impact testing equipment is widely used to determine a material's or part's service life and evaluate an object's capacity to withstand high-rate loading. Impact resistance is among the most difficult qualities to measure. Impact tests come in two common varieties: Charpy and IZOD. Impact testing is used to determine a material's toughness. The capacity of a material to absorb energy through plastic deformation determines its toughness. [16] Because brittle materials can only withstand a certain degree of plastic deformation, they have inadequate toughness. Temperature has an affect on a substance's impact value as well. At very low temperatures, a

material's impact energy generally diminishes. The results of the Izod impact test may also be influenced by the specimen's size because a larger specimen may have more material flaws that could increase stress and decrease impact energy. According to the Izard test result analysis, using increasing percentages of Ammonium polyphosphate in relation to PLA and jute improves the impact test results.

Table 2- Ammonium polyphosphate tensile test analysis results

Sr.No.	Sample	Impact Test (Jules)
1	(80 PLA -20 coconut shell powder-0 Ammonium polyphosphate)	7.63
2	(79 PLA -20 coconut shell powder -1 Ammonium polyphosphate)	7.14
3	(78 PLA - 20 coconut shell powder - 2 Ammonium polyphosphate)	5.43
4	(77 PLA- 20 coconut shell powder - 3 Ammonium polyphosphate)	8

3. Flame retardance Test

Testing for oxygen index reduction is mostly used to determine the combustibility of a substance. This test determines the lowest ambient oxygen concentration necessary to maintain material combustion at a marginal level. This is accomplished by loading the sample with an oxygen and nitrogen mixture and placing it in a chamber with a combustion wand attached. The critical oxygen level is found by lowering the oxygen content inside the testing facility until the flame stops. [27] Samples having a higher critical oxygen fraction are less flammable. The UL-94 fire retardance test standards for biodegradable composite materials must be followed. It is known as the flammability test when composite materials are burned. Utilizing the Underwriters Laboratories test standard UL 94, or standard flow, we conduct two different sorts of tests: 1. Vertical burning test and 2. Horizontal burning test. In the former, we check the rating V-0, V-1, and V-2 for the way that burns and its characteristics.

The material classes' naming standards are explained in further depth in the sections that follow. Preconditioning VB at 70°C for 168 hours is required, as stated in the official testing method paper: "material classified as 5VA

or 5VB is subjected to a flame ignition source that is approximately five times more severe than that used in the V-0, V-1, V-2, and HB tests."

Table 3: Ammonium polyphosphate fire retardant analysis results

Sr.No	Sample	Fire Retardancy
1	(80 PLA -20 coconut shell powder-0 Ammonium polyphosphate)	55% (Burning Rate)
2	(79 PLA -20 coconut shell powder -1 Ammonium polyphosphate)	54% (Burning Rate)
3	(78 PLA - 20 coconut shell powder - 2 Ammonium polyphosphate)	52% (Burning Rate)
4	(77 PLA- 20 coconut shell powder - 3 Ammonium polyphosphate)	50% (Burning Rate)

IV -CONCLUSION

The flame-retardant properties of powdered coconut shell were investigated in this research. Ammonium polyphosphate was one of the flame-retardant substances that was evaluated; it was mixed with coconut shell powder to form experimental panels. 20% coconut shell powder, four fire retardant concentration levels (0, 1, 2, and 3%), and resin based on oven dry fibre weight were used to create the experimental panels. Tensile and impact tests conducted by mechanical means were analysed. The study's findings demonstrated that PLA's tensile and impact strengths dropped when the flame retardant was introduced. The maximum concentration of ammonium polyphosphate enhanced the fire retardant more than the lowest.

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