INVESTIGATION ON TENSILE, FLEXURAL STRENGTH OFPOLYLACTIC ACID BASED NANOCOMPOSITES

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Abstract - *Our project motive is to increase the overall properties of by adding inorganic fillers such as copper oxide and PLA three specimen of different matrix were prepared by moulding process and it is subjected to examination to obtain their tensile strength, in addition to that, the microscopic analysis is operated to observe the fracture surface of specimen and the properties of the various specimen was compared and it is recorded*

Key Words: *PLA and Copper Oxide.*

1. INTRODUCTION

The occurrence of fracture commonly occurs in our daily lives, for example, the dish breaks into several pieces when accidently dropped on the floor. In the package industry, the package of food can be opened by tearing. In case of fracture occurs, some of these instances are spontaneous and others are controlled by people and mostly due to the mechanism of the design. Metal and non-metal material is widely used in our common lives and especially polymer material has increased significantly in last fifty years. In this research, Polylactic acid (PLA) is mainly focused on. PLA is widely used in packaging industry. The food packaging industry, PLA is widely used and has been applied in Packaging for food and beverages for many years. Currently, PLA cover are installed more than the other plastic cover. In the last twenty years, PLA have also been used as a protection layer for cables in construction structure to prevent corrosion.

1.1 INTRODUCTION ABOUT POLYLACTIC ACID

Polylactic acid (PLA) is a type of biodegradable polymer that is derived from renewable resources such as cornstarch or sugarcane. It is a popular alternative to traditional plastics, which are derived from fossil fuels and have a significant negative impact on the environment. PLA is considered to be an environmentally friendly option because it is made from renewable resources and can break down into natural components over time. This means that it is less likely to contribute to the accumulation of plastic waste in landfills or oceans. In addition to its eco-friendliness, PLA also has a wide range of applications. It can be used to make packaging materials, disposable cutlery, food containers, and even 3D printing filaments. PLA has gained popularity in various industries due to its versatility and compatibility with existing manufacturing processes. However, it's important to note that PLA is not without its limitations. It can be more expensive to produce compared to traditional plastics, and it has certain limitations in terms of temperature resistance and durability Overall.

1.1.1 PROPERTIES OF POLYLACTIC ACID

Polylactic acid (PLA) is a type of biodegradable polymer made from renewable resources, such as corn starch or sugarcane. Here are some key properties of polylactic acid:

- Biodegradability: PLA is known for its biodegradability, meaning it can be broken down by microorganisms in the environment, unlike traditional plastics.
- Renewable Resource: PLA is derived from renewable resources, making it more sustainable than petroleum-based plastics.
- Transparency: PLA has good transparency, making it suitable for transparent or translucent applications. • Strength and Rigidity: PLA has good tensile strength and rigidity, which makes it suitable for a wide range of applications
- Temperature Sensitivity: PLA has a relatively low melting point, typically around 150-160 degrees Celsius, which should be considered when choosing PLA for hightemperature applications.
- Limited Chemical Resistance: PLA is not resistant to most organic solvents and has limited resistance to moisture, so it may not be suitable for certain environments or applications.
- Processability: PLA can be processed using various techniques, such as injection molding or 3D printing, making it versatile for different manufacturing processes.
- It's important to note that specific properties of PLA can vary depending on the grade or formulation being used

1.1.2 ADVANTAGES OF PLA

Polylactic acid (PLA) has several advantages that make it an attractive alternative to traditional plastics. Here are some key advantages of polylactic acid:

- **Biodegradability:** PLA is fully biodegradable and can be broken down by microorganisms in the plastics that can take hundreds of years to decompose
- **Renewable Resource**: PLA is derived from renewable resources such as corn starch or sugarcane, making it a more environmentally friendly choice. It helps reduce reliance on fossil fuels and supports the use of sustainable agricultural practices
- **Versatility:** PLA can be processed using various techniques like injection molding, blow molding, and 3D printing. This versatility allows for a wide range of applications in industries such as packaging, food and beverages, textiles, and biomedical.
- **Reduced Carbon Footprint**: PLA production emits fewer greenhouse gases compared to the production of conventional plastics. Using PLA can help reduce carbon emissions and mitigate climate change impact.
- **Good Printability**: PLA is widely used in the 3D printing industry due to its ease of printing and good layer adhesion. It has become a popular choice for professionals
- **Transparency:** PLA can be formulated to have good transparency, making it suitable for applications where visual appearance is important, such as packaging or display cases
- **Low Toxicity**: PLA is considered to have low toxicity and is generally safe for human contact. It is often used in food packaging and medical applications where safety is critical

1.1.3 APPLICATIONS OF PLA

Polylactic acid (PLA) has a wide range of applications due to its unique properties. Here are some common applications of PLA:

- **Packaging**: PLA is commonly used in packaging materials such as clamshells, trays, cups, and films. Its transparency and rigidity make it suitable for displaying and protecting various products.
- **Food and Beverage Containers:** PLA's low toxicity and biodegradability make it a popular choice for food and beverage containers like disposable cutlery, disposable plates, and cups. It is commonly used in the food service industry and at events.
- **Textiles:** PLA fibers can be used to make fabrics and textiles. These fibers can be blended with other natural or synthetic fibers to improve their mechanical properties and make sustainable clothing and accessories
- **Agriculture:** PLA mulch films are used in agriculture to reduce weed growth, retain soil moisture, and regulate soil temperature. These films can be left in the field and will biodegrade over time, eliminating the need for removal and disposal.
- **Medical and Pharmaceutical Applications:** PLA is utilized in medical and pharmaceutical applications such as sutures, drug delivery systems, tissue engineering scaffolds, and implants. Its biocompatibility and biodegradability make it suitable for these applications

1.2 COPPER OXIDE

This study aims to provide an updated survey of the main synthesis methods of copper oxide (CuO) Nano particles in order to obtain tailored nano systems for various biomedical applications. The synthesis approach significantly impacts the properties of such nano particles and their properties in turn have a significant impact on their biomedical applications. Although not widely investigated as an efficient drug delivery system, CuO nano particles have great biological properties including effective antimicrobial action against a wide range of pathogens and also drug resistant bacteria. These properties have led to the development of various approaches with direct applications to the biomedical field, It is also believed that these nano systems could represent efficient alternatives in the development of smart systems utilizing both detection of pathogens and for the treatment of infections

Copper oxide (CuO) nanoparticles were characterised and investigated for their potential antimicrobial applications. It was found that nano scaled CuO, generated by thermal plasma technology, contains traces of pure Cu and Cu2 O nanoparticles. Transmission electron microscopy (TEM) demonstrated particle sizes in the range 25–90 nm. TEM energy dispersive spectroscopy gave the ratio of copper to oxygen elements as 54.18% to 45.26%. The mean surface area was determined as 15.69 m2 /g by Brunau–Emmet–Teller (BET) analysis. CuO nano particles in suspension showed activity against a range of bacterial pathogens, including meticillin-resistant Staphylococcus aureus (MRSA) and Escherichia coli, with minimum bacteri- cidal concentrations (MBCs) ranging from 100 g/ml to 5000 g/mL. The ability of CuO nano particles to reduce bacterial populations to zero was enhanced in the presence of sub-MBC concentrations of silver nano particles. Studies of copper oxide CuO nano particles incorporated into polymers suggest release of ions may be required for optimum killing

Table -1: Sample Table format

Properties of copper oxide	
Boiling point	2000° C
Melting point	1325° C
Density	6.315g/mL
flammability	Non Flammable

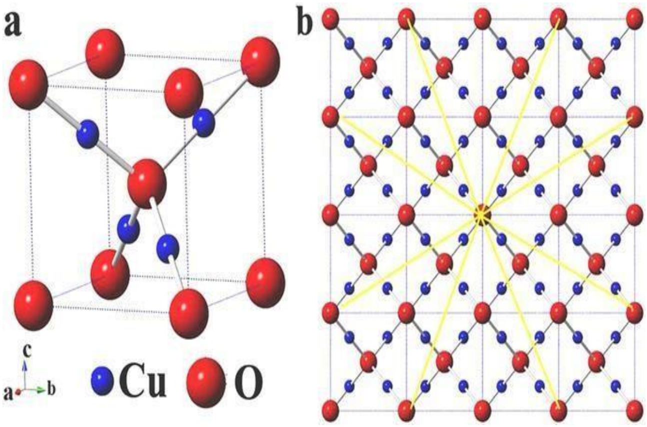

Fig -1: COPPER OXIDE - STRUCTURE

1.2.1 ADVANTAGES OF COPPER OXIDE

- Having a narrow band gap of 1.2 eV
- Energy conversion, Optoelectronic devices and catalyst.
- Super thermal conductivity, Photovoltaic properties, High stability, and Antimicrobial activity.
- Have other unique magnetic and super-hydrophobic properties.
- Have Semiconducting Property
- Useful in batteries, catalysis, solar energy conversion, high-temperature superconductors
- Copper oxide nano particles can improve the mechanical properties of the composite, such as stiffness, strength, and toughness.
- Copper oxide nano particles can improve the electrical and thermal conductivity of the composite.
- Copper oxide nano particles can improve the wear resistance and corrosion resistance of the composite.
- Copper oxide nano particles can improve the thermal stability of the composite.

2 INJECTION MOULDING:

Injection moulding of plastic creates high-quality three-dimensional objects that can be commercially reproduced. The injection moulding process start with melting plastic in a hopper. The melted, liquid plastic is injected into a tightly closed mould. The plastic quickly takes the shape of the surrounding mould. Once it has completely set, the mould is opened to release the plastic object. The mould can generally be used many times before needing to be replaced. Plastic items such as yogurt cups, butter tubs, plastic toys and bottle caps use the injection moulding process

2.1 VERTICAL INJECTION MOULDING:

Vertical injection moulding machines functions like traditional horizontal machines, however it's orientation is on the vertical axis. The available type of machine is as follows, hydraulic, electric and hybrid. Vertical injection moulding machines require little floor space due to the orientation of the machine. Vertical injection moulding machines are particularly suited for insert moulding applications. Components can be easily loaded intothe mould and held in place by gravity prior to over moulding. Vertical injection moulding machines often incorporate a shuttle or rotary table, allowing loading and de- moulding within the machines cycle time

Fig- 2: VERTICAL INJECTION MOULDING

2.2 MOULDING DIE SPECIMEN:

Dies and moulds are both tools for shaping. Dies are used to shape sheet metal and other metal forms. A typical application is the making of automobile bodyparts. On the other hand, moulds are used in injection moulding such as with melted resin or casting molten metal

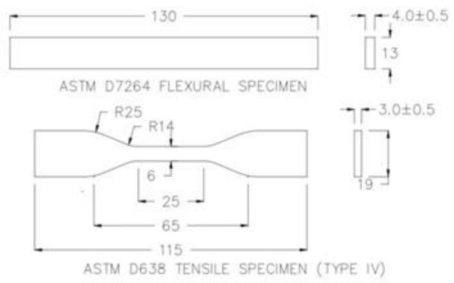

Fig- 3: TENSILE SPECIMEN

3 TESTING AND EVALUATION

3.1 FLEXURAL TESTING:

Flexural testing assesses a material's resistanceto bending, vital for understanding its flexibility and durability across applications like plastic lock arms and support beams.ASTM D790 and ISO 178 provide standardized procedures to determine flexural modulus, crucial for material selection and performance evaluation. Challenges in flexure testing include stress concentration at loading points and fretting wear, mitigated by four-point tests and innovative approaches like using polypropylene shims. Flexural testing,performed with two-point or three-point bending fixtures, operates in compression mode to determine the material's behavior under stress, from fixed strain limits to complete failure.

Fig- 4: FLEXURAL TESTING MACHINE

3.2 UNIVERSAL TESTING MACHINE

A Universal testing machine (UTM) is used to test the mechanical properties (tension, compression etc.) of a given test specimen by exerting tensile, compressive or transverse stresses. The machine has been named so because of the wide range of tests it can perform over different kind of material

Fig- 5: UNIVERSAL TESTING MACHINE

4. RESULTS AND DISCUSSION

We bought the material PLA and Copper oxide to mix itN with the following composition as stated below

Neat PLA 100gm

100gm PLA+ 1gm CuO

100gm PLA+ 3gm CuO

100gm PLA +5gm CuO

RESULT: TYPE:1<<TYPE:2<<TYPE:3<< As per the above composition the specen for tensile,compression and flexural will be prepared by injection moulding process. After that we planned to conduct thetensile,compression and flexural testing in the specimens using universal testing machine.

Fig- 6: BEFORE TENSILE TEST

Fig- 7: AFTER TENSILE TEST

Fig- 8: BEFORE FLEXURAL TEST

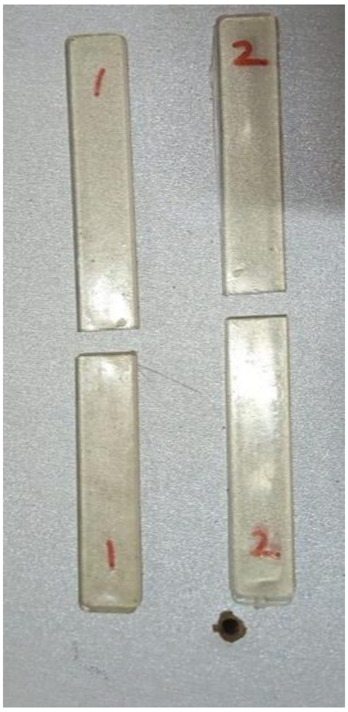

Fig- 9: AFTER FLEXURAL TEST

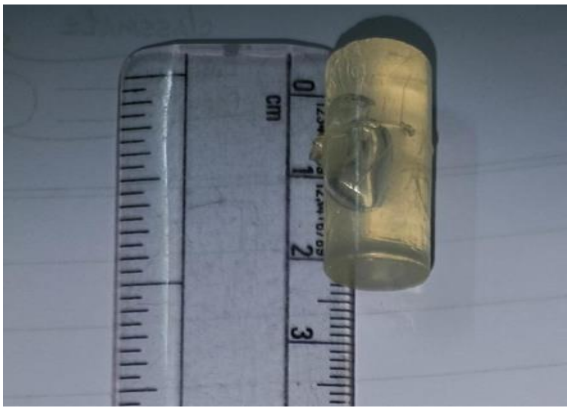

Fig- 10: BEFORE COMPRESSION TEST

Fig- 11: AFTER COMPRESSION TEST

4.1 TENSILE STRESS STRAIN CURVE:

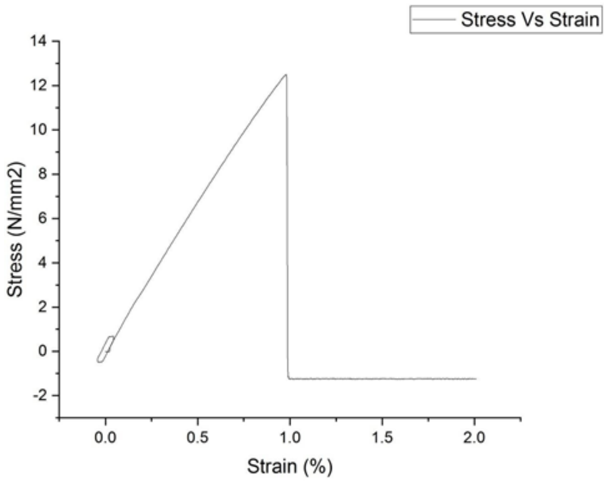

Chart – 1: STRESS VS STRAIN

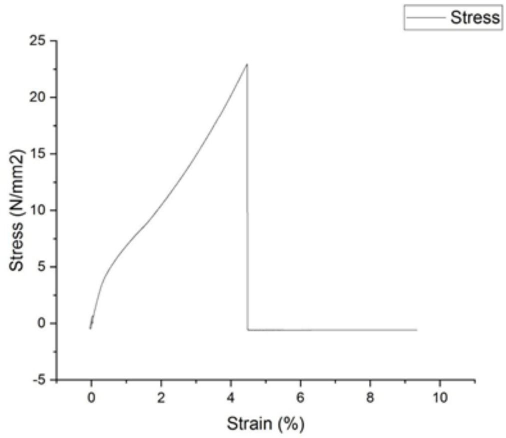

Chart – 2: STRESS VS STRAIN

4.2 FLEXURAL TEST GRAPH:

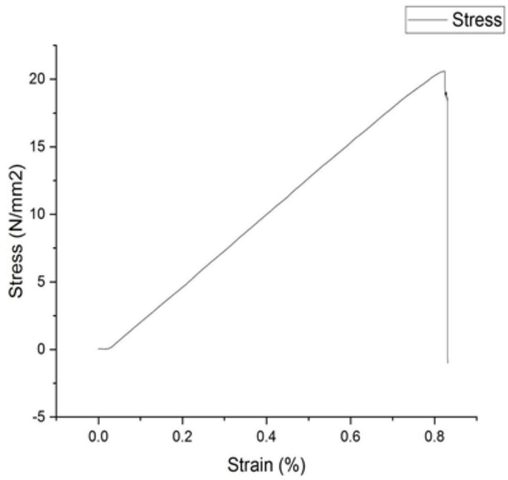

Chart – 3: STRESS VS STRAIN

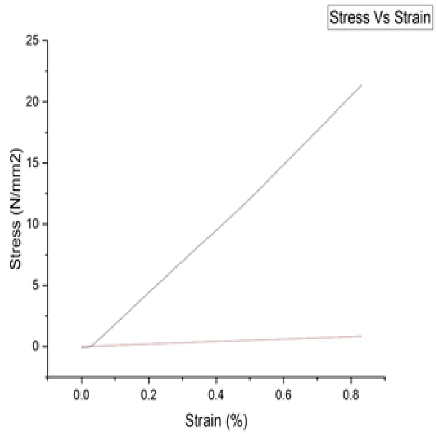

Chart – 4: STRESS VS STRAIN

4.3 COMPRESSION TEST GRAPHS:

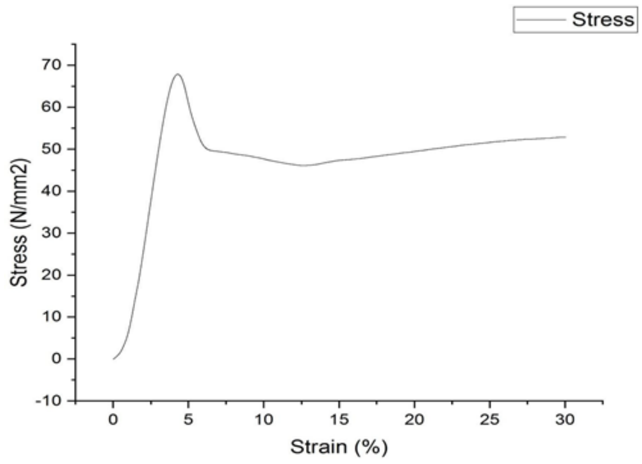

Chart – 5: STRESS VS STRAIN

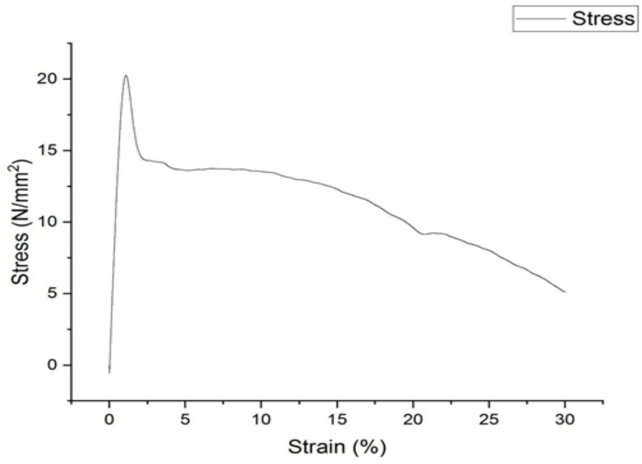

Chart – 6: STRESS VS STRAIN

5. CNCLUSIONS

Based on the investigation conducted on the tensile and flexural strength of polylactic acid (PLA) based nanocomposites, it can be concluded that incorporating nanoparticles has a significant effect on enhancing the mechanical properties of PLA. The nanocomposites exhibited improved tensile and flexural strength compared to pure PLA, indicating their potential for various applications requiring higher mechanical performance. The specific enhancements observed depend on factors such as nanoparticle type, size, and concentration. Further optimization and characterization are necessary to fully exploit the potential of these nanocomposites in practical applications.

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