Effect of Coarse Weeds Malaysia Grass Fiber on Mechanical and Biodegradation Properties of Thermoplastic Corn Starch Biocomposite

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ABSTRACT

Plastics are the main threat to the environment as they are non-biodegradable. Thermoplastic corn starch (TPCS) is a promising alternative material to replace the non-biodegradable. Therefore, in the current investigation, compression molding was used to insert weed grass fiber (WGF) into TPCS. Then, in order to assess the potential of WGF/TPCS biopolymer composites as a biodegradable reinforcement, the fundamental features of these materials were examined. According to the study, adding WGF to TPCS composites increased their tensile and flexural properties while lowering their impact strength and elongation. SEM demonstrates strong fiber adhesion between WGF and TPCS in terms of morphology. A test on soil burial reveals that adding WGF to TPCS has slowed the composites' biodegradation.

INTRODUCTION

The ecology is out of balance because the rate at which plastic garbage is produced greatly outpaces the rate at which it degrades. As leachate from plastic garbage escapes into a water reserve region, this phenomenon could result in water contamination and harm to all living things. All living things suffer catastrophic harm when waste plastics enter the food chain because they have an increased surface area and mobility due to UV irradiation and weathering [1]. Around 92% of synthetic plastics manufactured are polyethylene and polypropylene, which are used to make plastic bags, bottles, disposable containers, and packaging materials [1].

Biopolymer was created using a variety of renewable materials, including lipid, cellulose, protein, and starch. Starch is viewed as the most promising resource among these because it is inexpensive, widely accessible, adequately biodegradable, and renewable in nature.

Thermoplastic corn starch (TPCS) is biodegradable and eco-friendly and can replace non-biodegradable plastic in various applications [2]. TPCS has excellent barrier properties to water and oil and have a good thermal stability and high tensile strength but low density. TPCS had cost-effective in performance of product and can be easily molded into different shapes and sizes. Cornstarch has a high viscosity which makes it perfect for creating thermoplastic material that can be molded and reshaped [3]. The thickness of cornstarch allows it to bind together in a gel-like substance when heated, making it an ideal base for creating various types of plastic materials. The viscosity of cornstarch can be adjusted by adding water or another liquid to modify its consistency for different types of thermoplastic products.

Various types of natural fibers have been utilized as reinforcement in polymer composites, including cotton, flax, kenaf, hemp, ramie, sisal, sugar palm, and jute coir [4]. Coarse weed bio composites consist of natural fiber reinforcements obtained from agricultural waste. These fibers have low cost, low density, and good biodegradability, making them a promising alternative to traditional synthetic fibers. The mechanical properties of coarse weed bio composites depend on various factors, including fiber type, fiber length, orientation, and the matrix polymer. In polymer composites, the adhesion between the fibers and the matrix is critical for achieving good mechanical performance.

Coarse weed is a type of weed that grows abundantly in Malaysia. It is commonly found in open fields, along the roadsides, and in gardens. Coarse weed is known for its rough texture and coarse appearance. It is considered an invasive species and can be harmful to native plant species. Coarse weed can grow up to a height of three feet and has spiky leaves. It is difficult to control and can quickly overtake an area if not managed properly. Coarse weed can cause allergies in humans and is also toxic to livestock [4]. There are various methods for controlling coarse weed, including manual removal, herbicides, and grazing. It is important to manage the growth of coarse weed to prevent its spread and protect the local environment.

Polymer corn starch can be used as a binding agent for coarse weed fiber. The addition of polymer corn starch can improve the properties of coarse weed fiber composites, such as mechanical strength and water resistance. Polymer corn starch can also act as a filler for coarse weed fiber, enhancing its thermal and moisture properties. The use of polymer corn starch in combination with coarse weed fiber can lead to the development of sustainable and eco-friendly materials. Polymer corn starch and coarse weed fiber can potentially replace conventional synthetic materials in various applications, including packaging and construction.

EXPERIMENTAL

Materials

The coarse weed grass for this study was collected from the field area in Kulim, Kedah. The corn starch used in this study was purchased from a convenience store.

Sample Preparation

Thermoplastic corn starch (TPCS) was made by adding water (30% starch-based) and pre-mixing for five minutes with a mixer. After completing this first phase, the resulting blend was thermo-pressed to create a laminated plate with a 4 mm thickness. In order to achieve this, a plastic hydraulic molding press was run under a 98kN load for 35 minutes at 165 ^{0}C. For the creation of TPCS/WGF composites, the same procedure was applied. By integrating various CGF ratios (1, 3, and 5 wt%), the matrix's properties were modified. Coarse weed grass fiber (WGF) were extracted by using water retting process for 2 weeks. The retted leaves were washed in running water and the fibers were removed manually. The extracted fibers then undergone cleaning and drying under the sunlight. The dried fibers were cut into 1 cm length using scissors in order to serve as reinforcement. The fiber is then kept in zip locked bag until further process.

Measurements

Specimen of the tensile test was referred to ISO527-5. Three (3) replications of each wt.% of fiber were carried out for the test by using Universal Testing Machine; crosshead speed of machine was maintained at 5 mm/min. The results of the tensile properties were obtained by taking the average of the data.

Izod impact tests were conducted according to ASTM D256 at a temperature of 23 ± 1^{o}C and relative humidity of 50 ± 5%. The specimens were prepared with dimensions of 60 mm (L) x 13 mm (W) x 3mm (T). The tests were performed on five replications using a pendulum impact tester.

Impact strength = Impact energy (J) / area (mm^2)

SEM equipment with acceleration voltage of 10kV, was used to examine the morphology of the samples. The cracked surface of the tensile test specimen was identified for SEM analysis and stored in a zip-locked plastic bag after testing.

RESULTS AND DISCUSSION

Physical and Chemical Properties of Coarse Weed Grass Fiber (WGF)

In general, it can be seen that the WGF shows a rough surface and non-uniform structure in Figure 1. This might be attributed to the raw condition of the fiber which have not undergone any chemical treatment

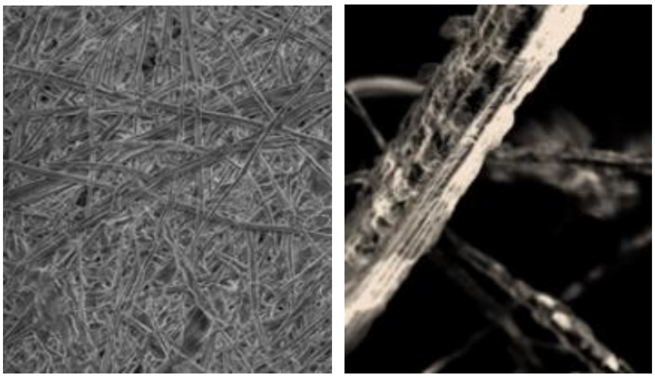

Figure 1. SEM of WGF.

Properties Thermoplastic of Corn Starch (TPCS)

Corn starch thermoplastic is a biodegradable material made from corn starch and other natural ingredients. It has gained popularity in recent years due to its environmental friendliness and potential to replace traditional petroleum-based plastics. One of the key properties that determine its usefulness in various applications is impact toughness.

Impact toughness is the ability of a material to absorb energy during a sudden impact without fracturing or breaking. In other words, it measures the ability of a material to resist crack propagation under stress. This property is important for materials that are used in impact-prone environments such as automotive components, packaging materials, and toys.

The impact toughness of corn starch thermoplastic is influenced by various factors such as the type and number of plasticizers, fillers, and other additives used in the manufacturing process. These factors affect the material's mechanical properties, morphology, and crystallinity. Known for instance that the addition of plasticizers such as glycerol or sorbitol can increase the flexibility and elongation at break of the material, thereby improving its impact toughness.

In conclusion, the impact toughness of corn starch thermoplastic is an important property that determines its usefulness in various applications. It can be improved by modifying the material's structure and morphology through the addition of plasticizers, fillers, and other additives, as well as by blending with other polymers and incorporating nanoparticles. These advancements in the manufacturing process are making corn starch thermoplastic an increasingly viable alternative to traditional petroleum-based plastics in a wide range of applications.

Furthermore, the impact toughness of corn starch thermoplastic can also be affected by the processing conditions such as temperature, pressure, and cooling rate. Optimizing these parameters can lead to improvements in the material's mechanical properties and thus its impact toughness. Additionally, the use of renewable resources in the production of corn starch thermoplastic makes it a more sustainable option compared to traditional plastics. This has led to increased interest in research and development of this material for various applications including food packaging, agricultural films, and disposable cutlery. As technology advances and more efficient manufacturing processes are developed, we can expect to see an even greater adoption of corn starch thermoplastic in the future.

Impact Properties of Thermoplastic Corn Starch and Coarse Weed Bio Composites

Due to its eco-friendliness, reusability, and sustainability, thermoplastic corn starch and coarse weed bio composites have attracted scientific interest. Their impact strength is one of the important characteristics that determines their applicability for different applications. Impact strength is the ability of a material to resist failure under dynamic loading. Several factors determine the impact strength of thermoplastic corn starch and coarse weed bio composites, including filler morphology, fillers' particle size, and the processing conditions. The use of coarse weed particles as fillers in thermoplastic corn starch matrices improves the impact strength of the bio composites. Coarse weed particles provide reinforcement due to their high aspect ratio, which leads to better load transfer and improved mechanical properties. Moreover, the incorporation of fillers into bio composites reduces the free volume available for rigid chain motion during an impact. Therefore, bio composite structures dissipate more energy during deformation, reducing the likelihood of crack propagation and failure. Lastly, the processing conditions, such as temperature, pressure, and cooling rate, play a vital role in determining the impact properties of bio composites. Proper control of processing conditions produces bio composites with the desired impact strength that can withstand the intended service conditions.

Soil Burial

The loss of weight resulting from moisture and microbial activity during the soil burial phase can be used to estimate the biodegradation characteristic of materials [4]. Result shows that percentage weight loss of thermoplastic corn starch with the addition of coarse weed grass fiber after soil burial for 1 and 2 weeks respectively. According to the findings, the TPCS/WGF composite exhibited a lower percentage change in weight than the TPCS matrix throughout the initial testing days. This reaction might be caused by the fiber of coarse weed grass or TPCS absorbing less water. As a material degrades, an increase in its hygroscopic property may promote the proliferation of microorganisms and accelerate the removal of material. Consequently, since WGF has a lower hydrophilic feature than TPCS, its stronger biodegradation resistance may be linked to the WGF/TPCS composites' reduced weight loss. According to this research, the coarse weed grass fiber exhibits more biodegradation resistance than the TPCS matrix.

RESULTS AND DISCUSSION

Benefits of TPCS and CWF

The potential benefits of using polymer corn starch and coarse weed fiber in place of conventional synthetic materials extend beyond just packaging and construction. This eco-friendly combination could also be utilized in the production of textiles, furniture, and even automotive parts. Additionally, the use of these sustainable materials could help to reduce waste and pollution in various industries. As research into this area continues, it is exciting to consider the possibilities for a more environmentally conscious future. The use of polymer corn starch and coarse weed fiber could also have a positive impact on the agricultural industry. By utilizing these materials, farmers could potentially reduce waste and create new revenue streams from their crops. The development of sustainable materials like these could also lead to new innovations in manufacturing and design, as companies strive to create products that are both functional and environmentally responsible. As consumers become more aware of the impact of their purchasing decisions on the environment, demand for eco-friendly products is likely to increase. This presents an opportunity for businesses to differentiate themselves by offering sustainable alternatives. While there are still challenges to be overcome in terms of scaling up production and making these materials cost-effective, the potential benefits make it an area worth exploring further. With continued research and investment, we may be able to create a more sustainable future for generations to come.

POTENTIAL OF TPCS

Some potential areas for further exploration and research in the field of cornstarch-based thermoplastics include Developing new methods for adjusting the viscosity of cornstarch to achieve different levels of thickness and consistency, which could open up new possibilities for creating unique types of plastic materials. Investigating ways to improve the durability and strength of cornstarch-based thermoplastics, which would make them more suitable for use in applications that require high levels of performance and reliability. Exploring the potential applications of cornstarch-based thermoplastics in emerging industries such as 3D printing, where their unique properties could offer significant advantages over traditional plastics. Studying the environmental impact of producing and using cornstarch-based thermoplastics on a larger scale, including factors such as energy consumption, waste generation, and greenhouse gas emissions. Collaborating with other industries and organizations to promote the use of cornstarch-based thermoplastics as a sustainable alternative to traditional plastics, helping to reduce plastic waste and support a cleaner environment.

CONCLUSION

Thermoplastic corn starch and coarse weed bio-composites have gained interest in the research community due to their eco-friendliness, renewability, and sustainability. One of the critical properties that determine their suitability for various applications is their impact strength. Impact strength is the ability of a material to resist failure under dynamic loading. Several factors determine the impact strength of thermoplastic corn starch and coarse weed bio composites, including filler morphology, fillers' particle size, and the processing conditions. The use of coarse weed particles as fillers in thermoplastic corn starch matrices improves the impact strength of the bio composites. Coarse weed particles provide reinforcement due to their high aspect ratio, which leads to better load transfer and improved mechanical properties. Moreover, the incorporation of fillers into bio composites reduces the free volume available for rigid chain motion during an impact. Therefore, bio composite structures dissipate more energy during deformation, reducing the likelihood of crack propagation and failure. Lastly, the processing conditions, such as temperature, pressure, and cooling rate, play a vital role in determining the impact properties of bio composites. Proper control of processing conditions produces bio composites with the desired impact strength that can withstand the intended service conditions.

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