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Ionizing Radiation Impact on the Mechanical Properties of a Wood-Plastic Composite: A Review

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Abstract: *This paper reviews the effect of radiation on the mechanical properties of WPC. WPC can be defined as mixture of wood in a polymer matrix. Composite that used in this research mainly consists of 40% polyethylene (PE), 50 % wood fiber and the rest is carbon black. The WPC were then irradiated and go through post extrusion process under required dose levels of 0, 50, 100, 150, 200 and 250 kGy with the aid of the electron beam treatment (EB). Soon after, the irradiated WPC then classified using a test called bending test which specify in third point bending test (ASTM D4761) along with scanning electron microscopy (SEM). It was checked that two factors are affected with the increasing dose level and they were ultimate strength and modulus of elasticity (MOE). Diagnosis on the morphology of polyethylene by the research found that there was significant difference between the radiated and irradiated surfaces.*

Keywords: Wood plastic composite, plant fiber, polyethylene, consumer

1. Introduction

This paper aims to investigate the characterization and properties needed in the production of the new wood plastic composite for the uses of consumer. The industry has step up their game in the past few years. They are producing and enhancing the quality of the wood plastic product along with the rapid increase in the new form of technology. Furthermore, WPCs have a low in strength to weight ratio because of its polymer matrix. An ample amount of research has been focused into improving the strength of PE based WPCs over the past decades. While the methods involved has gained so much attention due to its cost effective and high-performance method of enhancement, past researchers also come out with an idea of creating a thermoset WPCs. It was also found that to some extent, the degradation of the wood fibers should happen in a radiation crosslinked wood thermoplastic composite.

2. Literature Review

Sputter-coated

Sputter coating is a process where physical vapor deposition is used to apply a very thin or functional coating on a substrate. The benefits of sputter coating is the stable plasma created which in turn provides a more uniform deposition. In simple words, the coating is consistent and durable

Flexural test
Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. When a specimen is placed under flexural loading all three fundamental stresses are present and being observed. They were tensile, compressive and shear and so the flexural properties of a specimen are the result of the combined effect of all three stresses as well as the geometry of the specimen and the rate the load is applied.

FTIR spectrometer
FTIR spectroscopy is used to observe the functional group of the wood plastic composite before and after gamma radiation with a certain amount of scanning range and scanning rate. The purpose of technique used in the spectrometer is to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas.

Electron beam, EB
Electron beam defined as a process that required the usage of beta radiation, usually of high energy, basically to treat an object for a variety of purposes

ASTM
American society for testing and materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services

Scanning electron microscopy, SEM
SEM can be described as an electron microscope that produces image of the sample by scanning the surface with a focused beam of the electrons. In this study, images of the fractured surfaces of the polyethylene-based WPC material were taken using the SEM.

3. Research Methodology

Polyethylene based product was bought from the local store in specified measurement, 3.6 m (12') lengths and they were cut into 0.9 m (3') sections. The products earned were deck boards and rated for a 0.4 m (16") on the center span at 4.8 kPa (100 PSF). The boards were 14 cm in (5.5") wide, 2.54 cm (1") thick with an average density of 0.98 g/cm. The deck boards were a press composite blend of PE (40-50%), wood fiber (50-60%) and less than 1% carbon black by weight. The PE was essentially linear low density polyethylene (HDPE) that can be derived from recycled grocery bags and stretch film. The wood fibers are mainly decomposed from waste materials such furniture makers or recycled pallets.

The specimens were then transported and stored in a conditioning chamber at 21˚C (70˚F) and 50% relative humidity (RH) at the local laboratory. The specimens were weighed before and after storage, which resulted in a weight difference of less than 1%. Wafers 140 X 25 X 12.5 mm (5.5 X 1 X 0.5") in size were cut from an inside part of each of the original 0.9 m (12') deck boards. The wafers were placed in an oven at 103˚C (217˚F), until weight loss discontinued, then positioned in a desiccator to cool, before a final mass measurement conducted.

Third pound bending tests were handled by using Electomatic Universal Testing Machine, in accordance with ASTM D4761. A linear variable differential transformer (LVDT) conditioner was in place to detect deflection. The WPC specimens with specific measurements were irradiated with a Dynamitron 3.0 Mev, 90 kilowatt EB accelerator at local nearby industrial.

Nine replicates were considered at five different dose levels: 50, 100, 150, 200, 250 kGy and correlate against a control (0kGy). The samples were irradiated in air and to reassure the most uniform dose distribution, irradiated from both the front and back of each sample. The total doses to each board was applied in fractions of 50 kGy in order to avoid rapid temperature increases.

Images of the fractured surfaces of the PE-based WPC specimens were taken using SEM. The images were taken to monitor the fracture surface of the PE and wood fibers after EB treatment. The samples were then sputter coated in a 30 nm layer of platinum before micrograph analysis.

4. Conclusion

Based on the observation and test conducted in the research, it is confirmed that EB process on PE matrix is the best way to enhance the properties of wood plastic composite. This is because, EB treatment help to function in the improvement of strength and stiffness of the composite. Nevertheless, less cost needed when the usage of construction material is reduced and give other benefits in terms of environmental to the consumer. The suggestions are listed as follows. For instance, higher concentration of radiation dose is needed in future research involving this study. Taking into account, it will provide beneficial knowledge about the potential for advanced purpose. Besides, a whole bunch of mechanical testing such as hardness testing is crucial for the output performance of the product.

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