IMPROVING MECHANICAL AND THERMAL CONDUCTIVITY OF EPOXY RESIN BY THE ADDITION OF ECOFRIENDLY BIOCHAR DERIVED FROM COCONUT TREE

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Abstract

This work focuses on development of new type composite using biochar derived from Coconut tree produced by pyrolysis of the biomass at the temperature of 600°C for two hours as reinforcement of epoxy matrix. Because of the growing demand for waste utilization development of biochar from such wastes proves to be a potential one for various applications. In this study focuses bio char reinforced epoxy resin for composite fabrication prepared by solution dispersion method with different weight percentages such as 1, 3 and 6% were reinforced epoxy matrix. The prepared specimens are subjected to flexural strength, impact strength, hardness and thermal conductivity. Results shows that increased in all mechanical test and thermal conductivity at 6% weight of biochar

Keywords: Bio char, epoxy resin, Solution dispersion method, Flexural strength, Impact strength, Hardness and thermal conductivity

Introduction

Biomass has been diagnosed as a highly high-quality renewable power source, and is collecting attention because of its abundance, high quality environmental considerations, and waste reduction capacity (Camps et al., 2015). Biochar referred to as biocarbon or pyrolytic char is the solid, carbonaceous residue generated from the pyrolysis process. Similar to charcoal, it has an inherent strength fee if combusted, however, it differs inside the truth that charcoal is used historically to burn (Claoston et al., 2014). Biochar has gained hobby in recent years because of the capacity to use the material within the developing subject of bio composites; i.e. materials where one or extra of the components are organic in origin. This can imply the filler or polymer is made from renewable sources, along with plant fiber, recycled material, or waste vegetation and oils (Rajkovich et al., 2012). The surface area of biochar allows for stable matrices to develop at the polymer-filler interface, and the hydrophobic nature of biochar give it an advantage in compatibility when compared to other organic fillers such as wood (Manya, 2012).

The development of new structural and useful materials relying on ecofriendly (i.e., biochar) sources is specifically suitable in geographical areas where biomass and other biogenic wastes are abundant. Waste materials, received after removing natural components (e.g., carboxylic acids, phenols, aromatic hydrocarbon, ketons, alcohools, etc.) through pyrolysis, can be used as a new kind of carbon filler to increase the carbon percentage in the final products (Fornes et al., 2015). Biochar is a carbon wealthy material derived from pyrolysis of biomass. Scientific hobby on this fabric is due to its low cost and its extremely good availability (Kambo et al., 2015). Epoxy resins are used as high-tech materials because of their superb mechanical properties, chemical resistance, thermal stability, and occasional production value. Some examples of such applications are glues, adhesives, surface coatings, and electrical insulators (Naebe et al., 2014). However, epoxy resins have a negative thermal conductivity (0.15–0.25 W/m.K) (Khan et al., 2017). High-value carbon fillers together with carbon nanotubes and graphene are elaborate for large-scale packages. These carbon fillers set off an increment of its electrical and mechanical properties in the host polymer matrix but are not a appropriate choice for commercial scale production however it high-price. Thus, low cost carbon fillers which are not derived from fossil fuels, together with biochar are a subject of applicable hobby that product of heating biomass to a temperature of 400 – 800°C below the absence of oxygen (Liu et al., 2015).

Mauro Giorcelli et al. (2019) used Biochar derived from Maple tree and pyrolyzed at two different temperatures to prepare polymer composites based on epoxy resin at 1, 2, 4 and 20%. Morphological characterization on these two types of Biochar were done. Thermal treatment on Biochar permit to have two different Biochars to use in this work. In general addition of the carbon fillers increased the load bearing capacity of the epoxy matrix. The best results were achieved by 1 wt% addition of either Biochar concentration. Stiffness of the matrix was also enhanced by an addition of small amounts of Biochar.

In this examine the use of biochar that low price carbon fillers derived by Coconut tree. Mechanical houses and thermal conductivity had been investigated for complete composite characterization. Biochar is locating applications in composite/polymer sector

Material and Methods

The biochar derived from Coconut tree changed into used to fabricate bio char reinforced epoxy composites. The Coconut tree is burned within the furnace in 600°C for two hours. The glass mold became taken and carried out the wax inside the glass mold the floor of the glass mildew in 3mm thickness. The epoxy resin takes in the plastic beaker and blended with biochar with weight 1, 3, and 6%. After that the hardener delivered by the use of of curing composite plates for two hours. Finally eliminate the glass mold and get the bio char filled composite plates. The organized composite plates conduct on mechanical properties of, flexural, Impact, Hardness, and thermal conductivity.

Flexural strength

Using universal tester produced by Changshun Kexin Company, flexural strength test was implemented by reference to ASTM D790-2010, with fulcrum span of 64 mm and testing speed of 2 mm/min. The dimensions of the rectangular shaped flexural specimens were 80mm×20
mm x 3.2 mm with span length 48 mm. The flexural properties may be calculated by:

\[ \text{Flexural strength} = \frac{3FL}{2bd^2} \]  

Where; \( F \) = ultimate failure load in N, \( L \) = span of the supporting center in mm, \( b \) and \( d \) are the width and thickness of specimen for flexural test correspondingly in mm.

**Impact Strength**

The impact strength test was implemented by reference to HG/T 3841–2006, with the dimension of test specimen to be 170 mm x 10 mm x 4 mm, the energy of pendulum bob to be 2 J and impact speed of 2.5 m/s. In order to determine the response of specimens to sudden impact, the procedure of Charpy impact test had been utilized according to ASTM D256 and the tests were carried out after at least 40 h of notching.

**Hardness test**

The hardness of the polymeric composite is a critical parameter that influences the durability and lifespan of the material. A type-D Shore durometer was used to measure the samples, with a test range of 0 to 100 Shores according to the ASTM D2240 standard.

**Thermal Conductivity**

The measurements of \( K \) carried out under variable warmness according E1530 circular slab type HPC specimen diameter 150mm and thickness five mm to ten mm. A known value of heat is carried out from one side of the composite slab wait until the system reach constant state, the temperature of every interface surfaces were measured through thermocouples. Thermal conductivity coefficient turned into calculated to the statistics that measurement by way of the use of the lee's disk thermal conductivity coefficient was calculated with the aid of using the following:

\[ K \left[ \frac{T_b-T_A}{d_s} \right] = \frac{e}{2r} \left[ \frac{d_A}{d_A + d_s} \right] T_A + \frac{1}{2r} (d_s T_b) \] \( (2) \)

\[ H = IV = \pi r^2 e \]

\[ T_A + T_b + 2\pi r \left[ d_A T_A + \frac{1}{2} d_s (T_A + T_b) + d_b T_b + d_c T_C \right] \] \( (3) \)

Where

\( K \): Thermal conductivity Coefficient \((W/m°C)\), \( e \): Represents the amount of thermal energy passing through unit area per second disk material, \( H \): Represents the thermal energy passing through the heating coil unit of time, \( d \): Thickness of the disk \((mm)\), \( r \): The radius of the disk \((mm)\), \( d_s \): Thickness of the sample \((mm)\), \( T \): The temperature of the disk \((°C)\).

**Results and Discussion**

**Flexural strength**:

The Flexural strength of biochar bolstered Epoxy composite results plot a graph as proven in Fig (1). Different weight percentage of biochar addition of Epoxy matrix and their results substantially improved. The bio char particles had been dispersion with matrix to will increase of flexural energy to increase the filler content. To discover that maximum flexural energy was takes place on 6% filled composite. It was actually to boom the flexural energy that may motive with the aid of the bio char powder to shape as a great inter locking between the matrixes.
Thermal conductivity

Epoxy polymer low thermal conductivity (0.24 w/m⋅°C), therefore, many styles of high thermal conductivity substances are used as fillers to beautify the thermal of polymer material, when upload biochar from 1% to 6% increase thermal conductivity with growing ratio seem in Fig (4). The increase inside the thermal conductivity of the composite because of the higher thermal conductivity of biochar filler can also play a role, as it results in a decrease concentration (or quicker diffusion). Also biochar is a carbon (C)-rich byproduct produced in an oxygen-limited environment which has increasing thermal conductivity of composites. Biochar is made by means of heating biomass to a temperature of 400 – 800°C underneath the absence of oxygen. The method used is called pyrolysis, Highly carbonized biochar (>90 wt.% of carbon) is chemically stable under ambient conditions.

![Thermal Conductivity and % biochar of composites](image)

**Fig. 4**: Thermal Conductivity and % biochar of composites

**Conclusion**

Biochar derived from Coconut tree and pyrolyzed at 600 °C turned into used as filler, to put together polymer composites primarily based on epoxy resin. Morphological characterization, mechanical take a look at and thermal conductivity of Biochar were finished at 1, three and 6% composites. The addition of the carbon fillers multiplied the load bearing capacity of the epoxy matrix. The effects were executed through 6 wt% addition of Biochar awareness in mechanical (Flexure, Impact, Hardness) comparison with natural Epoxy and multiplied the thermal conductivity.

**References**


