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Composite Manufacturing from Recycled Medical Gloves Reinforced with Jute Fibre

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Abstract

The disposal of many rubbish materials affects the environment because they persist for a long period of time on the earth without degrading. Among the rubbish materials, medical gloves are the one that are disposed to the environment daily from different health centers all over the world. This leads to great environmental problems on soil, ground and surface water, plants, animals and human beings. Emission of bad odour and luck of storing place are the other problems of the disposed medical gloves into the landfills. The goal of this study is to recycle these disposable gloves and manufacture a full composite end product used for partition of shelves or different rooms.

In this investigation an attempt has been made to determine the recyclability of medical gloves. The study was done by using molten gloves reinforced with jute fabric, which impart better strength for the composite end product. Thermal sterilization method at a temperature of 100°C was used for disinfecting the medical gloves. After sterilization the gloves wear melted using metal pot and composite was manufactured using hand layup technique. The manufactured composites were tested to study the mechanical properties of the composite, tensile strength, flexural strength, impact strength and hardness. The mean tensile strength of the composite (563.009, 664.7577 MPa), the mean compression of composite (1.3, 2.47 MPa) and the mean bending strength (0.99, 1.35 MPa) were recorded for two and three jute fabric layer composite product respectively. The results indicated that the recycling of medical gloves under the use of composite manufacturing gives very strong end product functional for the partition purpose.

Keywords: Composite; Jute fiber; Recycling; Waste disposal; Mechanical properties

Introduction

Recycling is well-known for its environmental benefits, which include resource conservation, energy conservation and reductions in water and air pollution, including reductions in greenhouse gas generation. However, it also has significant economic benefits, many of which are often overlooked [1].

Recycling is an important segment of the national and state economy, creates jobs and saves money for generators of waste. The businesses, institutions and local government understand that recycling makes both environmental sense and economic sense [2].

Composites are combinations of two or more than two materials in which one of the materials, is reinforcing phase (fibers, sheets or particles) and the other is matrix phase (polymer, metal or ceramic).

Natural fiber composites possess the advantages such as easy availability, renewability of raw materials, low cost, light weight and high specific strength, and stiffness.

Jute fibers are extracted from the ribbon of the stem. It is used as packaging material (bags), carpet backing, ropes, and yarns and in many other decorative it [3].

A variety of industries currently use either natural or synthetic fibers in their products.

Many natural fibers have sufficient strength and stiffness but are difficult to deal with because of their fibrous structure and variable properties while most polymers do not have sufficient strength or stiffness but serve as a good adhesive to hold fibers together.

In composite structures, the fibers serve as the constituent that give the composite strength and stiffness, while the polymer matrix holds everything together and effectively transfers stresses to the fibers. These concepts are true for both synthetic based composites and natural based composites [4].

Mechanical properties, low weight, low cost, ecological sustainability, low energy requirements, biodegradability, and carbon dioxide neutrality are all driving factors in the push for natural fiber composites.

Materials and Methods

Collection of disposed gloves

In many health centers the gloves are discharged mainly in two major categories i.e. either a collecting box or container that store only non-contaminated gloves or a special box or container that can store only highly contaminated gloves like a blood having HIV infection.

Throughout the collection of gloves the first step is identifying the collection box of contaminated and non-contaminated gloves [5,6].

Then select the department that uses much number of gloves per day in the health center. Take two collection boxes randomly that store only non-contaminated gloves from each department that uses much number of gloves per day.

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Sterilization

Sterilization is the process that destroys or eliminates all forms of microbial life specially microorganism. After getting all the required number of gloves they, were sterilized to eliminate the harmful microorganism comes among them from the patients. Since the gloves are contaminated they should be sterilize first to make free from hazardous substances. Among the varying sterilizing methods Thermal sterilizing methods was used at a temperature of (100°C) because of its lowest cost and easy to apply [7]. Thermal sterilizing method is preferred because of its availability as compared to the other methods. Enough water was placed in a pot among the gloves and heat was applied on to it up to the sterilizing temperature was reached. Boiling was done for 10 min to ensure complete disappearance of the harmful microorganisms [8-10].

Drying, cutting and melting

Simply use either a dryer or sun light to remove the moisture content on the glove until complete removal of moisture. Scissors was used to cut the glove in to small pieces which will help for even layering or distributing of gloves over the pot during melting process [7]. When the gloves are changed into small pieces it does not stick layer to layer and melting becomes easy. The melting point of a substance is defined as the temperature at which the material changes from a solid to a liquid state [11-15]. Pure crystalline substances have a clear, sharply defined melting point.

The small pieces gloves are put in to pot and applying heat on it up to the melting temperature of acrylo nitrile butadiene [1800c] is reached. When the melting temperature is reached the nitrile, glove starts to melt and convert to molten solution [15-19]. Applying pressure or string is necessary to make all gloves melted enough equally and evenly from top of the pot to bottom of the Melter. When melting is not good some bade like structure is created on the composite product which makes rough surface and bad look on the end product [20]. Finally, by using different molds the sample is prepared and well dried, after that mechanical properties were studied [21].

Results and Discussion

According to ASTM D7205 "Standard Test Methods for Tensile Properties of Fiber-reinforced Polymer Matrix Composite Bars" the samples having specified thickness, diameter and length measured under universal tensile strength tester. For two jute fabrics layer composite product three samples wear taken for tensile strength testing and the data is taken from datasheet to draw its load versus displacement graphs. The data from each test was used to determine valuable material properties such as ultimate tensile strength (Tables 1 and 2). These material properties were used for comparing the materials to each other, and to define the material as brittle or ductile. Also, the jute fabric layer is studied which shown in Figure 1. As the result shows that if two number of jute fabric is added in the manufacturing of composite product it can resist over 1000 KN force but below 1400 KN without breakage (Table 3).

Sample No.	Sample Length (mm)	Sample Width (mm)	Area (mm^2)	Diameter of sample (mm)
1	225	12	2700	9.1
2	220	10	2200	9.1
3	215	8	1720	9.01

Table 1: Testing parameters for two jute fabric layer composite product.

This end product can use in different application area having load below this average maximum breaking load. Three samples of each composite were tested in the universal tensile strength taster frame, and the data gathered into an Excel spreadseet (Table 4). The data was used to calculate various properties of each material.

Bending test

According to ASTM D7264 "flexural Properties of Fiber-reinforced Polymer Matrix Composite" the samples should have a specified thickness, diameter and length and measured under universal tensile strength tester (Figure 2).

Time	Load	Displacement	Deform
0.06	990.95	0.01	0
0.17	1001.72	0.02	0.001
0.3	1001.72	0.04	0.004
0.39	1001.72	0.05	0.006
0.5	1001.72	0.06	0.007
0.61	1001.72	0.07	0.008
0.72	1012.49	0.09	0.011
0.83	1012.49	0.1	0.013
0.94	1012.49	0.11	0.014
1.04	1023.27	0.13	0.017

Table 2: Some excel data for two jute fabric layer composite product.

Sample no	Area (mm^2)	Area(m^2)	Maximum Load (KN)	Tensile strength MPa
1	2700	0.00027	1098.66	406.666
2	2200	0.00022	1271	577.7272
3	1720	0.000172	1357.17	700.953
Mean	2206.6	0.00022066	1242.2	563.009
value				

Table 3: Maximum load and tensile strength for two jute fabric layers.

Sample No.	Sample Length (mm)	Sample Width (mm)	Area (mm)	Diameter of sample (mm)
1	220	10.5	2310	10.2
2	221.5	10.3	2281.45	10.1
3	222	10	2220	10

Table 4: Testing parameters for three jute fabric layer composite product.

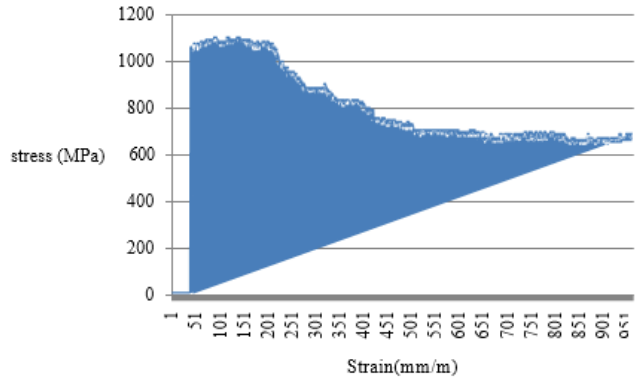

Figure 1: Stress versus strain for two jute fabric composites.

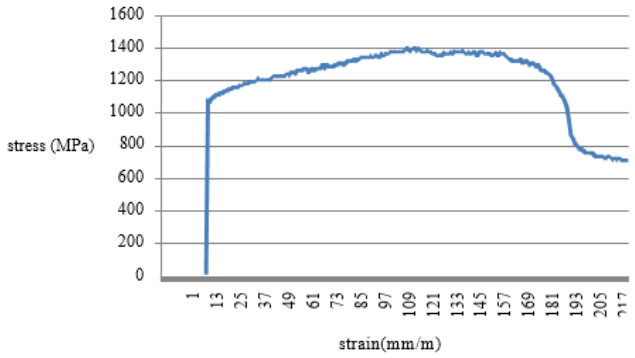

Figure 2: load versus displacement for three jute fabric layer bending test.

Compression

According to ASTM standard E9-09, E209 "standards test method of compression" some parameters like sample length, width and diameter should be set on the testing machine before start testing and compression is tested. Varying sterilizing methods Thermal sterilizing methods was used at a temperature of (100°C) because of its lowest cost and easy to apply. According to ASTM D7264 "flexural Properties of Fiber-reinforced Polymer Matrix Composite" the samples are studied in a specified thickness, diameter and length and measured under universal tensile strength tester.

Conclusion

Disposed medical gloves was a better resin agent for jute fabric and impart smooth and flat look for the end product without any crack on the surface of composite product. To manufacture a composite end product, it takes 2-2.30 hours in average to solidify it at room temperature for two and three jute fabric layers respectively. The mean tensile strength of the composite (563.009, 664.7577 Mpa), the mean compression of composite (1.3, 2.47 Mpa) and the mean bending strength (0.99, 1.35 Mpa) were recorded for two and three jute fabric layer composite product respectively. When the properties of the end product were studied better results was recorded for all tests including tensile strength, bending and compression.

Since the properties were good enough recycling of those disposed medical gloves and use for composite manufacturing was show successful result to reduce accumulation of used gloves from the environment and also to get useful end product from waste gloves.

When the amount of jute fabric increases the composite mechanical strength also increases and vice versa.

Disclosure

Abebu Nega is currently working as Lecturer in Textile Chemistry at kombolcha institute of Technology, wollo university, Ethiopia. Amare Worku is currently working as Lecturer in Textile Chemistry at Dire Dawa Institute of Technology (DDIT), Dire Dawa University, Dire Dawa, and Ethiopia.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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