Development of Banana Fiber Composite Reinforced with Multifunctional Synthetic Fibers for Multipurposes

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1. Introduction

Mankind has been strongly dependent on plant fibers for all kind of purposes. The usage of natural fibers has been reported from earlier days and they have served a wide range of uses (Preethi and Balakrishna Murthy, 2013).The recent arrival of synthetic products is being looked over the natural once as they are readily available and its low cost. But the biggest problem with these synthetic fibers is that they harm the nature by causing serious pollution as they are non-degradable. In India, many of the natural ligno-cellulosic fibres are considered as low value fibres useful only for manufacturing industrial ropes and fabrics for packaging. Banana is one such natural ligno-cellulosic natural fibre (Albarelli *et al.*, 2011). Natural fibres present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. The stem of banana plant is usually thrown away once the plantain is harvested. The stem forms a major waste material in large-scale banana plantations and for the large scale farmers, the disposal of the stem is a real problem (Mohapatra*et al.*, 2010). Fibre can be extracted from banana stem both manually and by mechanical extractor (Bankar*et al.*, 2010; González-Montelongo *et al.*, 2010). They are generally ligno-cellulosic, consisting of helically wound cellulose microfibrils in amorphous matrix of lignin and hemicellulose. After removal of these non-cellulosic components, the fibre bundles present a complex, hierarchically micro-ordered structure formed by micro-sized fibres with two orientations (Padam *et al.*, 2014). The cellulose content serves as a deciding factor for mechanical properties along with microfibril angle (Vivekanand *et al.*, 2011; Kumar and Kumar, 2011; Rijswijk *et al.*, 2001).

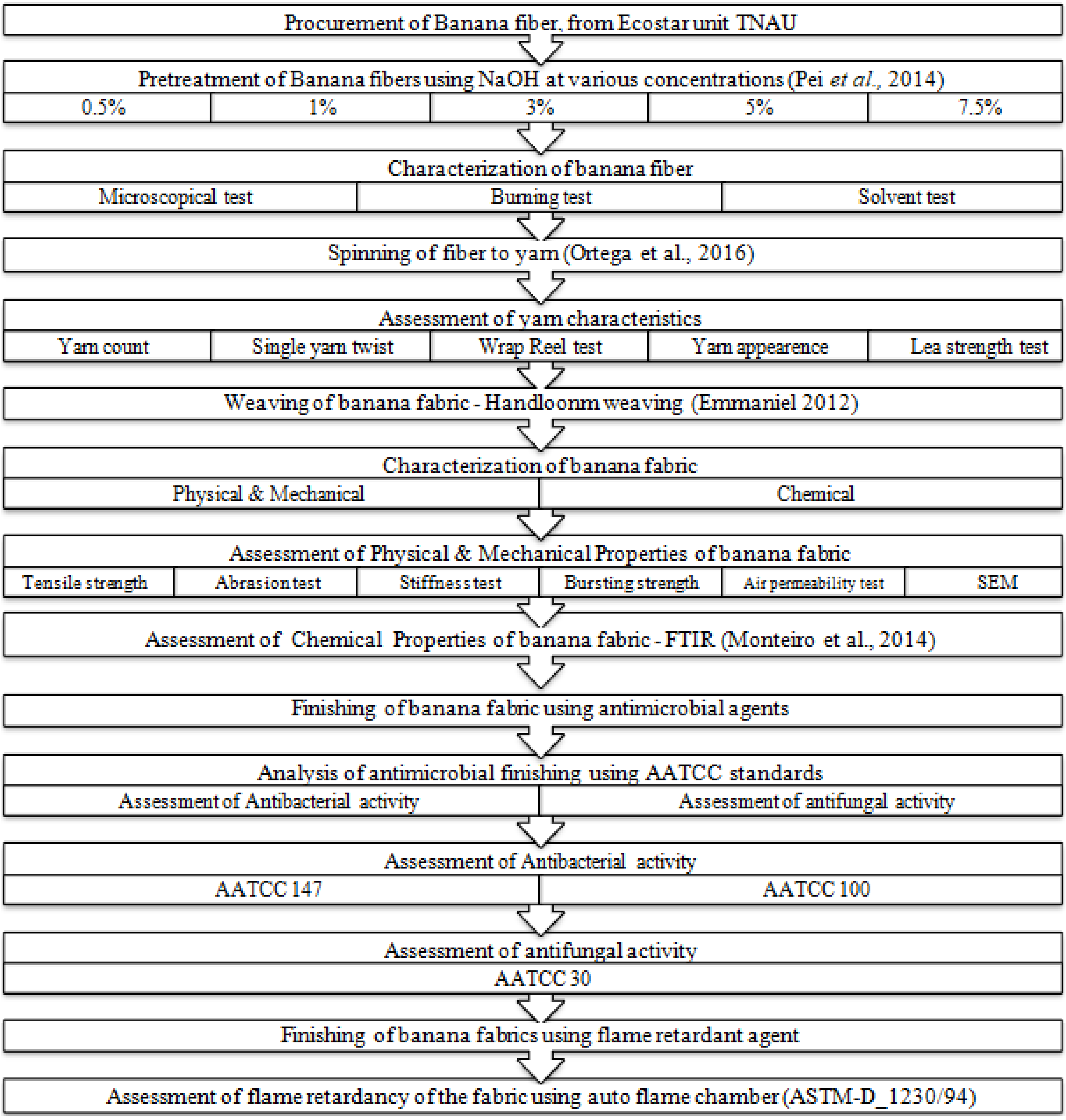
This study aims in developing technical textiles that can serve multipurpose uses like soundproof, fireproof and antimicrobial at the same time.The flame resistance of a textile fiber is affected by the chemical nature of the fiber; ease of combustion; fabric weight and construction; efficiency of the flame retardant; environment; and laundering conditions (Basak e*t al.*, 2015). The use of natural fibers would be of great importance because of its strength and composition. The commercially available flame retardant Ecoflame CT6 was used to finish the fabric and its flame resistance was evaluated using auto flame chamber.When providing such kind of functional finishes to the fabric, the need for longer shelf life is important. Keeping this in mind the finished fabrics were also given an antimicrobial finish using commercially available antimicrobial agents (González-Montelongo *et al.*, 2010; Salah, 2012). By doing so the finished fabrics would have a longer shelf life and reduces the damage of the fabricated material (Pal *et al.*, 2016).Owing to the effects of noise pollution several places such as schools, hospitals and certain commercial buildings require suitable acoustical engineering facility to overcome the problem. The advancement of controlling noise by sound absorptionoffers a great opportunity to study the acoustic attenuationtechnique of various porous materials (Mamtaz *et al*., 2016). The fibrous materials used can be either natural orsynthetic, the advantage of using acoustic panels made from natural fibers areless hazardous to human health and more eco-friendly thanthose made of synthetic fibers. Therefore,growing concern for human health and safety issues hasencouraged manufacturers and engineers to seek alternativematerials from natural fibers as a replacement for syntheticfibers.Thus, the present study aims in developing an acoustic material using banana fibers reinforced with synthetic polymers and explore its acoustic nature to improve the stability (Pathak*et al.*, 2016).The study therefore aims in developing of multifunctional finishes using banana fiber reinforced with synthetic polymers. The material developed will thus be antimicrobial, flame retardant and sound absorbing material. These multifunctional finished fabrics would be a demand in many industrial products such as lining materials in coolants, washing machines and high end equipment to prevent the accidental damages and increasing the lifespan of the materials. These kind of multi-functioned fabrics can be much use in entertainment hall like theaters as the material will be an acoustic, flame retardant thereby minimizing the effect of fire accidents and the antimicrobial property of the fabrics provide them a long life and replacement of these fabrics often can be reduced.

2. Objectives

- To extract the fibers from Banana pseudo-stem and pre-treat them and analyze the characteristics of banana fiber
- To spin yarn from fibers and to develop fabrics and to check it properties
- To analyze the physical, chemical and functional properties of the developed banana fabric.

- To study the flame retardant property of banana fibers and develop a flame retardant fabrics using chemical retardants
- To explore the natural antimicrobial activity of banana fabrics and to develop a antimicrobial finish using commercial antimicrobial agents.
- To develop various polymeric composites and reinforce banana fabric with the significant combination
- To explore the ability of the developed polymeric composite reinforced banana fabrics in sound proofing and develop a acoustic material
- To evaluate the acoustic property using impedence tube method
- To explore the uses of multifunctional finished fabrics in industrial textiles.

Phase I



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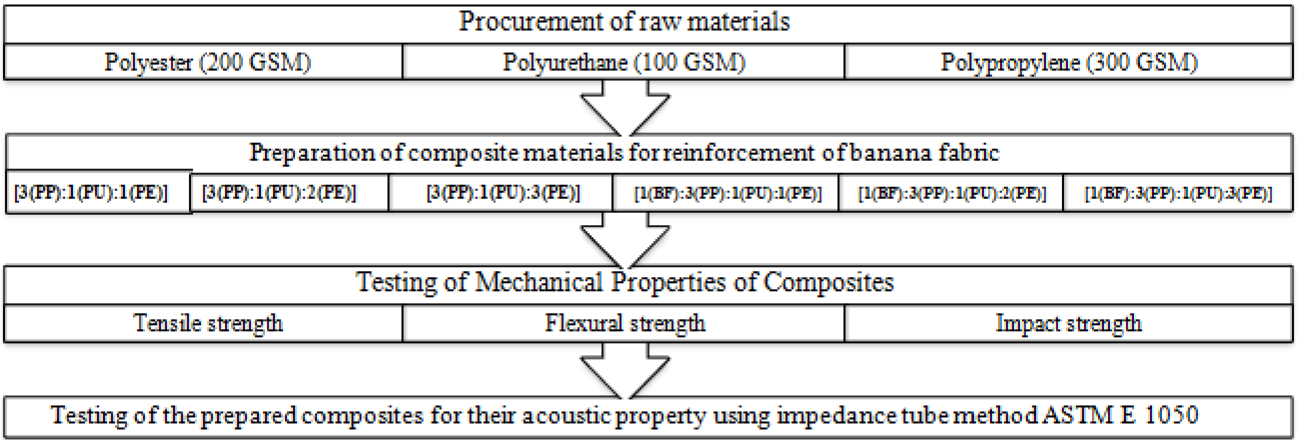
Phase –II



3. Results

The polymers and fibers used for the study were procured and processed before the use. The procured banana fibers were pre-treated with various concentration of sodium hydroxide for removing the components that hinder is activity. Among, various concentrations used 5 % of NaOH showed better yield and better processed fibers. The pretreated fibers were then spun to yarn and characterized. The yarn was then weaved using handloom weaving which was used for the study. Weaved fabric was characterized physically and chemically. The physical parameters such as pilling resistance, fabric weight measurement, measurements of yarn count, twist per inch measurement, tensile strength, measurement of fiber strength and elongation and scanning electron microscopy were performed and the results are as follows. The score of pilling resistance was 4 which appearedto be slightly pilled. The fabric weight was found to be 65.0Grams/Sq. Meter. The yarn count was measured in which the wrap count was found to be 78.1 D and weft count was found to be 76.3s Ne. The twist per inch of the fabric was measured and was found that the warp count was 13.8 and weft was 36.8 TPI. Measurement of Tensile strength was observed to 3.2 and 6.7 in case of warp and weft CV% respectively. Strength and elongation of fibers were measured in which the Single Thread Strength was about 53.2 % CV and elongation was 12.5 % CV. The scanning electron microscopy showed that the topography of the fibers was fine and few fractures were found which was due to the chemical treatment of the fibers. To analyze its chemical nature Fourier transmission infrared spectroscopy was performed which showed the presence of cellulosic content which was revealed through the presence of hydroxyl groups. The presence of C-H and C=O stretches revealed that the fibres are natural fibres.Weaved fabric has a significant physical, chemical and mechanical properties so it was then explored for its application as technical textile.As natural fibers have good absorption ability and because of the strength of this material, it was subjected to explore its ability to be used as flame retardant fabric. Therefore, commercially available flame retardant chemical Ecoflame CT6 was used to finish the fabric. The chemical was finished using pad-dry cure method at a curing temperature of 130-160° C at a curing time of 30 minutes. The finished fabric was used to study the flame retardency property which showed that the fabric (5×15 cm) charred after seven seconds of ignition. This showed that the fabric has an efficient flame retarding property and was classified under class I type of fabric according to ASTM-D_1230/94 method. Thus, the fabricated material was found to be flame retardant and in order to enhance its shelf-life and protect from the microbial attack, antimicrobial agents can be used to finish the fabric.

The natural fibers has been explored for its potential as technical textile which could be used in various machines and commercial buildings as it can serve as flame retardant material which could reduce the accidents caused due to short circuits and other damages. Though, it has these properties, in order to increase its shelf life finishing the material with antimicrobial agents would be the most appropriate. Therefore, the banana fabrics were finished with commercially available antimicrobial agent AB1000 which showed significant resistance against both Gram positive (18mm) and Gram negative (21mm) bacteria and mixed fungal spores. The results of AATCC 147 also showed that the fabric had good antibacterial effect of 15mm against *E.coli* and 17mm against *S.aureus*, similarly AATCC 100 method showed approximately 98% reduction in case of both the strains. The soil burial test showed that the fabric when finished with AB1000 has good strength in the fibers even after 9 days under the soil. This revealed the finished fabric had an efficient antimicrobial property. The fabric finished with both antimicrobial agent and flame retardant agent was characterized using scanning electron microscopy which showed the presence of the compounds coated on to the surface of the fibers. The physical properties of the finished fabric such as tensile strength and pilling resistance were checked which showed that the properties of treated fabric did not change much after treatment. The pilling resistance was the same which scored 4, which implies a slight pilling, whereas the tensile strength the warp and weft CV% were 5.2 and 7.9 respectively which was slightly different from the untreated fabric.In this regard, in order to combat noise pollution sound proofing fabrics were developed in combining these fabrics with synthetic polymers. Therefore, six different composites were prepared using banana fabrics, polyester, polyurethane and polypropylene foam sheets in different ratios. The composites were analysed for their mechanical properties using standard procedures. Tensile strength, flexural strength and impact strength were checked for all developed composites and the one with better efficacy was used for the study. The absorption property by using the impedance tube method which revealed the composite [1(BF):3(PP):1(PU):1(PE)] showed a significant average sound absorption coefficient of 0.17, which indicates that only 17% of the sound waves were reflected whereas 83% was absorbed by the composite. This is due to the presence of the cellulosic material of the banana fabric and fibrous nature of the chosen synthetic foam Polypropylene. As the composition of polypropylene was high among the other foam this enabled the sound absorption efficacy better as when it was used as single it showed the highest sound absorbing efficacy of 0.7%. So this combination along with banana fabric would be the apt composite for efficient sound proofing. Several studies have also mentioned that the higher amounts of fibre volume fraction are affecting frequencies broadening, hence promising better sound absorbing capacity (Abdullah*et al.*, 2015). Various machines such as washing machines can use this as insulating material which could reduce the noise caused due to motor and reduce the damage due to short circuiting.Therefore, the present study aimed in developing multifunctional finishes using banana fiber reinforced with synthetic polymers. The material developed will thus be antimicrobial, flame retardant and sound absorbing material. These multifunctional finished fabrics would be a demand in many industrial products such as lining materials in coolants, washing machines and high end equipment. These kind of multifunctioned fabrics can be much use in entertainment hall like theaters and other interior designing work in buildings as the material will be an acoustic, flame retardant thereby minimizing the effect of fire accidents and the antimicrobial property of the fabrics provide them a long life and replacement of these fabrics often can be reduced.The detailed results of all the aspects with the discussion, statistical interpretation, graphs, plates and figures will be presented in the main thesis.

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