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Introduction

Nature has abundance of natural fibres that are renewable. Natural fibres are very essential to meet the environmental challenges that are growing every day in the field of technical textiles. Environmental friendly materials have come under consideration as a result of rising awareness, public interest, new environmental regulations, and unsustainable petroleum use. Synthetic fibres destroy the environment due to their non-biodegradable and polluting nature, which leads to the utilization of natural fibre-based materials. In the last few years, natural resources have been considered as alternatives to synthetic fibres in several engineering applications. Natural fibres are being utilized as reinforcements along with the polymer matrix for composite manufacturing for their distinctive advantages over synthetic materials with essential properties such as strength, better stiffness, lightweight, biodegradability, thermal insulation, abundance, low cost, nonabrasive, and nontoxic nature. For thousands of years, plant fibres have been a kind of renewable source that has been renewed by nature within their variation in properties and characterization (Ramesh *et al.*, 2017).

Degradable biomaterials from plant sources are used to reduce environmental pollution in composite manufacturing (Sun *et al.,* 2017). Also, natural fibres have high performance in their mechanical properties, easy availability, renewability, recyclability, carbon dioxide neutrality, non-toxicity, low energy consumption, and low cost (Morales *et al.,* 2017). Natural fibres are the ideal alternatives that might be used in the composites sector because of their adaptability, environmental friendliness, affordability, renewability, and local availability (Stevens and Mussig 2010). This is the reason for researchers to focus their explorations on ecofriendly, green, and biocomposite materials, and many studies are being undertaken to fulfill industrial needs with eco-friendly materials. The age of the plant, the species, the growth environment, the harvesting, the humidity, the quality of the soil, the temperature, and the processing procedures have a significant impact on the quality of natural fibres.

Natural fibres have a lower density than glass fibres, which makes it possible to create lightweight composites. As a result, there is an increase in demand for natural fibre-based composites in industries across the world. Hemp, sisal, jute, and cotton are the most popular natural fibres. Plant fibres are lignocellulosic, which largely consists of cellulose, hemicellulose, pectin, and lignin (Thwe and Liao, 2003). These lignocellulosic fibres are advantageous not only because they are biodegradable, renewable, nonabrasive, consume less energy, and have a high strength and elasticity modulus, but also because they don't produce any waste when burnt. These have strong heat conductivity, making it possible to alternate glass and carbon fibres for composite materials (Neto *et al.*, 2019). A biocomposite is a material made of resin as the matrix and reinforcement from natural fibres (Mohanty *et al.*, 2002).

The plant fibres are obtained from different portions of the plant, like the leaf, stem, seed, and fruit. The plant *Abutilon indicum,* known by different names such as Paniyara Hutti, Thuthi (Tamil), Perum Tutti, Kanghi (Hindi), Jhapi (Bengali), and Tutti (Kannada) (Raja and Kailasam, 2015) yields fibres from the bast part of the plant that are soft and flexible. *Agave americana* is primarily known as a succulent plant which grows in tropical, subtropical, and temperate regions of the world. The fibres obtained from the leaf portion of the plant find application in composite materials, paper making, nonwoven fabrics, and geotextiles (Prabhakar, 2012). The *Arecanut* from the species *Areca Catechu Linnaeusunder*, yields fibre from its fruit portion, and these fibres are used for making value added products like fluffy cushions and thick boards (Sunny and Rajan, 2021). Natural fibres are hydrophilic in nature, which causes them to absorb more moisture and makes them incompatible with the polymer matrix (Nurazzi *et al.*, 2021). Due to the presence of hydroxyl groups, natural fibres are particularly polar and may easily form hydrogen bonds with other resin matrices (Li *et al.*, 2007). Combining natural fibres with matrices is challenging because they must maintain their thermal stability even at high processing temperature (Kumar *et al.*, 2017a). These challenges could be overcome by carrying out fibre surface modification utilizing physical, chemical, or biological treatment.

The chemical process enhances the interfacial adhesion between the polymer matrix and the fibre surface. Chemical processes such as "acetylation, alkylation, methylation, cyanoethylation, benzoylation, permanganate treatment and acrylation" are carried out for lowering the moisture content in the fibres (Bhantnagar, *et al.*, 2015; Khan *et al.*, 2013). This chemical process enhances the mechanical, physical, and thermal characteristics of the natural fibres resulting in better end products. Biological treatments are done by using pectinase and cellulase enzymes on natural fibres as these are advantageous for their eco friendly nature and also aid in producing fibres with fine qualities. The effect of enzymatic treatments on natural fibres should not be judged by their mechanical properties alone, but the mechanical characterization of the composites (Saleem *et al*., 2008). The positive effect of enzymatic treatments on composite performance is investigated by very few researchers, and there is a need to analyse the effect of enzymes on natural fibres while performing pretreatment and producing final composites. Cellulases are widely used in textile wet processing to modify the surface of fibre and fabric (Cavaco-Paulo, *et al., 1997*). When eliminating non-cellulose compounds from the surface of fibres, pectinases are an effective substitute for sodium hydroxide (Presa and Tavcer, 2008). Natural fibre-reinforced composites are becoming more popular as a result of their benefits, including low cost, biodegradability, eco-friendliness, reasonably excellent mechanical qualities, and an increased focus on the environmental and sustainability aspects of engineering materials (Lotfi *et al.*, 2021). In recent decades, there has been a lot of interest in the production of composite materials using natural fibres from both renewable and non-renewable resources, such as jute, flax, sisal, and oil palm (Hossain *et al.*, 2013). Each natural fibre has its own physical and chemical properties. So the blending of fibres with unique qualities when combined, will fulfill the lacking property in the other, in turn assisting in the best product preparation. The blend of fibres obtained from different parts, like bast, leaf, and fruit, when combined, will give the best results. The nonwovens are engineered fabrics that satisfy the needs of technical textiles for interiors in mobile tech and built tech (Savitha *et al.*, 2021). Needle-punched nonwoven materials with additional functional properties can be widely used in several technical applications, such as filters, composites, protective clothing, packaging, geotextiles, home furnishings, and heat and noise insulation. The presence of more fibres per unit volume opens up greater possibilities for sound waves to interact with the fibres. The sound insulation qualities of needle punched nonwoven textiles with higher densities are superior to nonwoven fabrics with lower densities (Maity and Singha, 2012).

These natural fibres would be easy to handle when converted into yarn or fabric. The nonwoven technique is a process in which the fibres are directly converted into fabric and it is more cost effective than other methods of fabrication. It is carried out by different techniques, namely mechanical bonding, thermal bonding, and chemical bonding. Needle punching is the oldest mechanical bonding technique in which fabric is made from webs of fibres by penetration of needles. The upward and downward movements of the needles will interlock the fibres together.

A thermoplastic component must be present for thermal bonding, whether it takes the form of a homofil fibre, powder, film, web, hot melt, or sheath as part of a bicomponent fibre. The thermoplastic component is heated until it melts, at which point surface tension and capillary action cause the polymer to flow (Malik *et al.,* 2018). Both thermoplastic polymers and blends comprising fibres not meant to soften when heated are used to create thermally bonded nonwovens. Low-melt fibres are widely used as binders in this type of fabrication. One such low melt fibres is polyethylene terephthalate (PET) fibre with a melting temperature varying between 245 and 265 IC (Ziabicki, 1996). Composite materials have led to an innovative field of materials by disclosing previously unknown heterogeneous materials. It is a type of structural material that is made by fusing two or more different components. When made from natural fibres, they have the advantage of being sustainable and will require less energy for production. They provide the benefits of being light weight, affordable, robust and safe in addition to being biodegradable and renewable (Asma *et al.,* 2020).

Fibre-reinforced polymer composites have had a huge surge in demand over the past few decades due to their remarkable combination of high performance, considerable versatility, and processing advantages at favorable costs through permutation and combination of different fibres and polymers (Mishra and Biswas 2013). In many engineering applications, hybrid composite materials are being utilized in increasing quantities because they have a number of superior characteristics that are beneficial over conventional composite materials. In order to create hybrid composites, two or more distinct varieties of fibres must be incorporated into the same matrix. These composites also find applications in aerospace, automobile construction, and marine applications due to their positive qualities of one kind of fibre complementing the lacking properties of the other. This mixing of fibres is done at any stage before composite preparation and can be in any fabricated form such as woven, nonwoven, knitted, braided, or fibres.

Researchers have been working to demonstrate the value of ecofriendly fibres in comparison to the use of synthetic, glass, and carbon fibres in recent years. Compression molding is the oldest and most extensively used method for creating composites. Other methods include injection molding and pultrusion. Thermosets have a low melt flow index but require high pressure to cure, and hence compression molding is selected for these polymers (Nithin, 2019). The polymer matrix composites have many advantages, such as low cost, low density, and lesser abrasiveness. Their limitation is that these materials are not biodegradable, but this can also be partially achieved as degradable composites (Gowda *et al.,* 2018). The classic variety of thermoset polymer is epoxy resin, which is manufactured through polymerization and used as adhesives in composite preparation. The main advantages of epoxy resins over unsaturated polyester resins include lower shrinkage, superior mechanical properties, resistance to corrosive liquids and environments, superior electrical properties, good performance at high temperatures, and good adhesion to substrates. Epoxy resins can be fabricated to yield a variety of different products with varying properties (Ray *et al.*, 2016). The most widely adopted "epoxy resin (LY556)" and industrial application "hardener (HY951)" are employed in industrial applications to fabricate laminated sheets and hybrid combinations. These resins are mostly used for their high mechanical properties and high corrosion resistance (Muthukumar *et al.*, 2014). In order to achieve maximum efficiency at the lowest feasible cost, the new "care-free structures" theory in the aerospace industry suggests that optimized structures should be developed. This approach is strongly tied to the potential of polymeric hybrid composites (Khanam *et al.,* 2010).

Currently, composites have entered nearly all major industrial, commercial, and domestic sectors (Abilash and Sivapragash, 2013). Acoustic materials assist in preventing undesirable sounds from affecting the human ear, and these have major potential in build tech, mobile tech, and home tech applications. Nonwoven structures have good acoustic and thermal properties and when converted into composite structures, these can be easily utilized for applications in buildings. With stronger stiffness and torsion properties than conventional materials like steel and aluminum, composite materials have four to six times greater tensile strengths. Biopolymer composites are used in wide variety of products nowadays. Considering the above facts, the study entitled "**Modification and Fabrication of Selected Natural Fibres into Thermal Bonded Structures for Hybrid Polymer Composites"** has been undertaken as an attempt to make materials that would be suitable for application as building components in the future. This research work focuses on the manufacture of biomaterial reinforced composite structures after fibre surface modification and blending to prepare hybrid materials with the following objectives;

- To understand the prevailing problems and the need for natural fibre made building materials over the existing ones
- To select natural fibres based on local availability
- To choose appropriate surface modification technique to enhance natural fibre functionality for the creation of compatible composite materials
- To select appropriate treatment method for fibre surface modification
- To fabricate and evaluate nonwoven structures utilizing surface modified natural fibre blends
- To develop natural fibre reinforced hybrid composite materials utilizing the prepared nonwoven structures
- To characterize the composite structures
- To select the nonwoven material reinforced polymer composite structures
- To evaluate the selected composite material for performing specific functional properties
- To obtain the feedback for the composite slabs to be utilized for build tech