POTENTIAL OF SUGAR PALM FIBER AS REINFORCEMENT IN NATURAL FIBER REINFORCED COMPOSITE : A COMPREHENSIVE REVIEW

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Abstract

Due to the urge of developing environmentally friendly materials, researches in new dimensions evolved .This new dimension focuses on developing eco friendly material with good mechanical strength. In This work is an endeavor made to highlight the potential use of sugar palm fiber as reinforcement in manufacturing of composites. How fibre loading affects the tensile properties is also discussed .Effect of different treatment like alkaline treatment, microwave treatment ,silane treatment, pre impregnation on tensile properties also discussed. It put light on effect of combining other fibres with sugar palm fibre on different tensile properties of hybrid Composite. Recent researches showing the applications of sugar palm fibre as a promising material for reinforcement in composite also discussed. Certainly, this review will open up new dimensions towards the structural applications of SPF and will help engineers researchers to explore the used of Composite in different sectors like automotive, packaging etc.

Keywords -Alkali treatment, Sugar palm fibre, Eco-friendly material

Introduction

Due to growing environment awareness and Regulation on carbon emissions, recycling [55] the used one and environment friendly disposal of used materials ,provoked the need of development of natural products. In case of composite, the choice of fibers whether synthetic fibre or natural fiber decides the properties and end use of the composites .Demand for renewable, cost-effective, and eco-friendly materials pushed the research from synthetic and glass fiber composite to the direction of natural fiber composites. Different natural fibers like jute (Khan L.P.1996,Wang X.2019), kenaf (Edeerozey A.M.2007,Jamadi 2020), khulum fibre (Sarak2021),coir (Nam T.H.2011,Hadi2019),sisal(Francis 2020),abaca(Hadi et.al 2019),hemp(Kostic M.2008,Haghinghatnia2017,Kabir 2013),banana rachis (Zuluanga 2009),banana fibre(Jandas 2013) ,Agave American fibre (Madhu P. 2020),Wheat straw(Sun R.1996) ,Date palm fibre (Alwar A 2009,Almaadeed M. A. et.al 2013) ,Corn husk fibre (Saenghirunwattana et.al 2014), palm empty fruit bunch (Norul Izani et.al 2013),snake grass fibre (Vijayakumar 2021,Thiruvasagm 2017),Borrasss (Boopathi 2012) ,Cocus nucifera leaf (Dubey N.2015),cane fibre polyster (Chikauche et.al 2015),Luffa fibre(Demir H.et.al 2006),coconut fibre (Hemsri 2012) have proved their capabilities as reinforcement in preparing composites for different applications. Apart from these ,SPF(Arenga pinnata) is well known in rural areas for its traditional uses but it's potential is much more than that. It is a promising material for preparing composites. Sugar palm tree which are found in abundance mainly in areas of South east are heat and drought resistant as they have ability to not lose much water.It has excellent thermal stability which can be utilized in structural applications. At present its use is mainly limited to domestic application. But its potential is need to be explored . Numerous researches have been done on it which shows that it's potential can be harnessed using different matrix ,different surface treatment , different coupling agents ,and different fillers [5].It's different morphological parts: bunch, trunk, frond ,ijuk (surface of the trunk) have showed excellent properties as per literature .Ishak et al. (2012) reported moisture content in sugar palm fibre is 5.36 % to 8.7 % which is lower than other competitive fibre. This review highlights the engineering properties and applications of sugar palm fibre reinforced composites.. It will lead the future research in the field of sugar palm fibre and SPF reinforced thermoset/thermoplastic/biopolymer composites.

2.Effect of fibre loading on tensile properties

2.1 Tensile Modulus E'$_c$ and Fibre Loading

Different researchers have been working on various combinations of sugar palm parts with different matrices and varying different factors like fibre loading, temperature, treatments etc.

Mohammed and others (2016 ,2018) in their work on sugar palm fibre and TPPU reported significant tensile modulus value 1307.562MPa(at 6% NaOH ,70^{0}C temperature)and 440 MPa with 2% NaOH and 30% fibre loading.[26,27]Suraini and others (2021) found that tensile modulus value 145.42MPa with SPF /PET with epoxy resin.[44]Sastra and others (2007) worked on the composite made up of spf and Epoxy resin and reported tensile modulus as1255.825 MPa.[40] Saupan and others (2012) have chosen different fibre loading to find tensile modulus of Sugar palm fibre reinforced epoxy HIPS composite .They reported tensile modulus as 1270MPa,1516MPa,1618MPa,1706MPa,1662MPa,1652MPa for sugar palm fibre weight 0%,10%,20%,30%40%50% respectively.[38] Hadi and others (2018) in their work on SPF/PP composite reported tensile modulus as 798MPa ,948MPa,1025MPa, 1275MPa for 0%,10%,20%,30% fibre weight respectively.[14] Misri and others (2010) reported tensile modulus as 1586.4896MPa for sugar palm fiber while 1840.6339MPa for SPF/glass fibre [25].Oumar and others (2014) worked on SPF and HIPS composite and found the values of tensile modulus for 0%,8%,17%,26%,35%,45% fibre loading as 1.27GPa,1.52GPa,1.62GPa,1.71GPa,1.66GPa,1.65GPa. [33]

2.2 Tensile Strength σ'$_c$ and Fibre Loading

Many researchers have been worked on different parts of sugar palm tree to be used in composite and measured the tensile strength for engineering application.

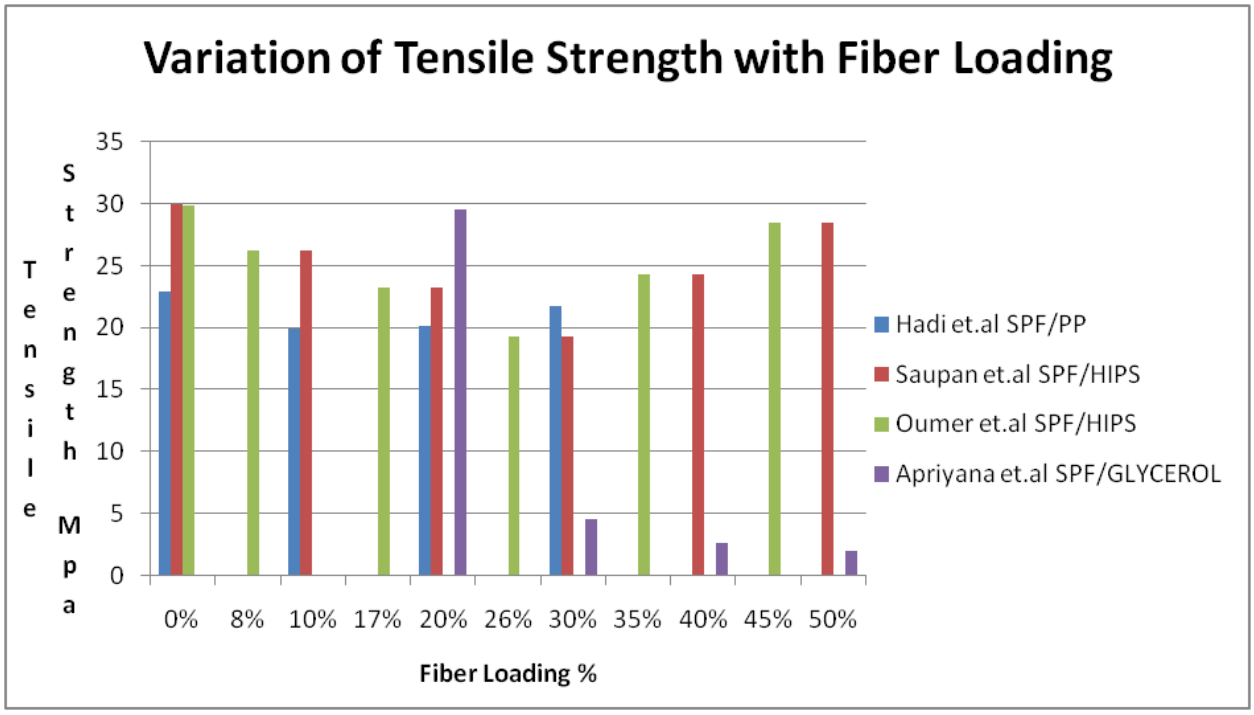
Hadi and others 2019 worked on sugar palm fibre reinforced polypropylene SPF/PP composite and found tensile strength as 20.07MPa,21.73MPa for 10% and 20% fibre loading respectively [14] while Apriyana and others 2016 worked on SPF/Glycerol composite and found tensile strength as 29.49 MPa and 4.54 MPa for 10%and 20% fibre loading respectively. They reported a decline in tensile strength for increase in fibre weight percent[2] Oumer and others (2014) worked on SPF/HIPS composite and found the tensile strength for different fibre loading 0%,8%,17%,26%,35%,45% and found that for 8% fibre loading the tensile strength was 29.9MPa and for 45% fibre loading tensile strength was 28.47MPa.[33].Ammar and others (2018) worked on knowing the effect of fibre direction on the tensile strength of SPF composite they reported maximum tensile strength for unidirectional fibre while $0^0/90^0$woven and +-45degree woven sugar palm fibre showed lower tensile strength as 11.65MPa and 15.67MPa respectively. They concluded unidirectional fibre orientation as best fibre orientation.[1]Saupan and others (2012) worked on Sugar palm fibre reinforced epoxy HIPS composite and studied the effect of fibre loading on tensile strength and found tensile strength minimum as 19.3 MPa for 30% fibre wt% and 28.47 MPa for 50% fibre wt%.[39]Sahari and others (2012) worked on different parts of the sugar palm tree such as sugar palm fibre, trunk, bunch, ijuk. They found maximum tensile strength for SP frond and minimum tensile strength for SP trunk .[35] Sastra and others (2007) worked on SPF/Epoxy composite and found tensile strength 51.725MPa for 10 wt % fibre loading [40]Mohammed and others (2016) (2018)worked on thermoplastic polyurethane (TPPU) reinforced with SPF composite. They found tensile strength as 14.01MPa for the composite and 11MPa for pure TPPU. Thus a significant rise in tensile strength is reported. [26][27] The composites reinforced with SPF are compiled in table 1{Hadi et. al (2019),Saupan et.al(2010),Saupan et.al(2012),Sastra et.al(2006), Ammar et.al2019), Apriyana et. al (2016),Suraini et.al(2007),Sahari et.al(2012) ,Mohammed et.al(2016,2018)}

Table 1 Studies on Sugar Palm Fibre as a Reinforcing fibre

S.N.	Fibre	Matrix	
1	SPF	Polypropylene	Hadi et.al
2	SPF	high impact polystyrene(HIPS)	Saupan et.al
3	SPF	high impact polystyrene(HIPS)	Oumer et.al
4	SPF	Vinyl ester(VE)	Ammar et.al
5	SPF	Epoxy	Sastra et.al
6	SPF	ThermoPlastic Polyurethane	Mohammed et.al
7	SPF/PET	Epoxy	Suraini et.al
8	SPF	Glycerol	Apriyana et.al
9	SPparts	…	Sahari et.al

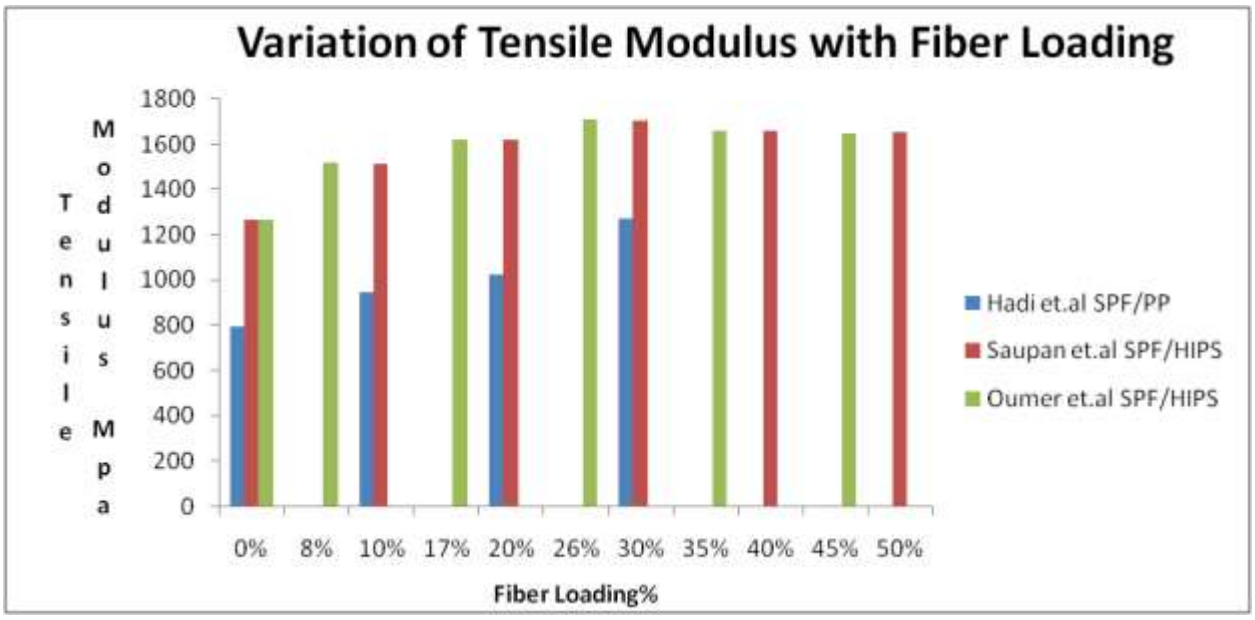
Graph 1 depicts researches taken for tensile strength variation with different fibre loading considering other factors constant. It is clear that maximum tensile strength is shown by SPF /Epoxy for fibre loading 10% while work on SPF/HIPS shows almost similar result for different group of researchers.

Graph1



Graph 2 depicts the effect of varying fibre loading on spf reinforced composite with different matrices considering other factors constant. It is quite obvious that polypropylene matrix showed lower values of tensile strength than High impact polypropylene matrix HIPS when used with Sugar palm fibre reinforcement.

Graph 2



Application of SPF

Applications of spf are reflected in table 2.Sanyang et. al(2018),Misri et. al(2010),Zaid et. al (2009) showed the utility of SPF in preparing composites .

Table 2 Applications of SPF

S.N.	Applications	References	SPF composite
1	Packaging industry	Sanyang and others 2018	Sugar palm starch based biopolymers
2	Small boats	Misri et al.2010	Sugar palm fibre and glass-reinforced unsaturated polyester
3	Helmet	Zaid 2009	Sugar palm fibre (Ijuk) reinforced thermoset

Limitations of SPF

1.Hydrophilic nature

2.Poor interfacial adhesion

3.Less durable

To overcome the Above mentioned limitations of SPF composites researchers are trying different alternatives like surface modification techniques and seawater treatment. (Ishak e.al 2009),alkaline treatment (Saupan et.al 2010), matrix Preimpregnation process (Ishak et.al2011a),Silane treatment (Zahari2015).

Gaps and Future recommendation

A lot of work has been done in the field of natural fibre reinforced composite but still there are possibilities of developing new exciting material with SPF as reinforcement.

Different combinations of reinforcing fibre along with SPF could be used to prepare hybrid composites and so boost the properties of Composites.

Different matrices, especially eco-friendly matrices can be used to develop biodegradable Composites which in turn help to achieve environment conservation.

Conclusions

Sugar palm fibre has shown its excellent potential in yielding materials with reduced cost and weight. It has been used as reinforcement with various matrix like epoxy (Bachtiar et al 2008 ,suraini et al 2007),Vinyl ester (Ammar et. al 2019),Unsaturated polyester(ishak et. al 2014) to prepare Composite which showed excellent Mechanical properties.Its excellent thermal properties can be explored more to prepare parts of heat engine and heat shield.By varying matrix,fillers, coupling agents, treatment better frp composite could be obtained.SPF can be used with other fibres to make hybrid Composite which will boost the thermal , mechanical, chemical properties of end product. Its potential is still to be harnessed .It could be a good substitute of Synthetic fibres and non biodegradable plastics. Its superior properties will certainly help Composite engineers, researchers, manufacturers in developing environment friendly materials for a better tomorrow in future.

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