

# **Valorizing darbha grass fibre to develop eco friendly bio-nanocomposite based on PP / EPDM for impact resistant application**

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# Introduction

## Thermoplastic

- Density
- Impact Resistance
- Heat resistance



## Elastomers

- Good tear strength
- Resilience



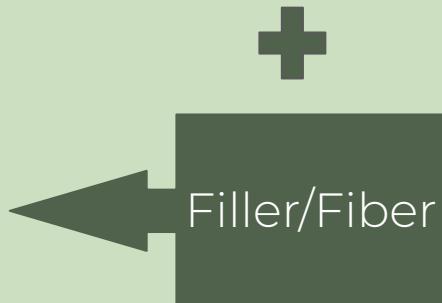
## Thermoplastic elastomers

- Toughness
- Tensile Strength
- Impact resistance



- Toughness
- Tensile strength

## Thermoplastic elastomeric composites



# Review of literature

SI No.	Title of the paper	Author	Remarks
1	The impact resistance of composite materials — a review	W.J.Cantwell & J.Morton Virginia Polytechnic Institute and State University, USA (1991.)	<ul style="list-style-type: none"><li>• To discover the essential characteristics that determine the impact resistance of continuous fiber-reinforced composite materials.</li><li>• The impact of changing the characteristics of the fibre, matrix, and interphase on the dynamic response of these materials is investigated.</li></ul>
2	Progress of novel techniques for lightweight automobile applications through innovative eco-friendly composite materials: A review. <i>Journal of Thermoplastic Composite Materials</i> . SAGE Publications Ltd.	Agarwal, J., Sahoo, S., Mohanty, S., & Nayak, S. K. Laboratory for Advanced Research in Polymeric Materials (LARPM) (2020, July 1)	<ul style="list-style-type: none"><li>• Natural fiber-reinforced composites are the excellent alternatives to the synthetic fiber-strengthened composites.</li><li>• Advantages- low cost and density, weight reduction, design flexibility, and green conduct</li><li>• Disadvantages - less durability and are hydrophilic in nature.</li></ul>

3	Polypropylene Compounds for Automotive Applications	Moritomi, Satoru, Tsuyoshi Watanabe, and Susumu Kanzaki. Sumitomo Chemical Co., Ltd. Petrochemicals Research Laboratory (2010)	<ul style="list-style-type: none"> <li>● Engineering plastics and metals have been extensively replaced by polypropylene (PP) based materials in automotive parts in order to achieve weight reductions and cost savings.</li> <li>● To accomplish this, PP compounds which are made from PP and other components are under intense investigation.</li> <li>● In this paper, the progress of research into compounding technology, improvement of mechanical properties and functionalization have been reviewed.</li> </ul>
4	An experimental study on the behavior of PP/EPDM/JUTE composites in impact, tensile and bending loadings	S.M.R. Khalili, R. Eslami Farsani and S. Rafiezadeh Centre of Excellence for Research in Advanced Materials and Structures, Faculty of Mechanical Engineering, K.N. Toosi University of Technology, Tehran, Iran. (2011)	<ul style="list-style-type: none"> <li>● The results show that by adding EPDM to PP, the impact strength is increased</li> <li>● The elongation at break is also increased for all the specimens, but the tensile and bending strength are decreased.</li> <li>● By adding higher values of wt% of jute fibers, the tensile properties are improved and the impact and bending strengths are reduced as compared with pure PP.</li> </ul>

# Gaps Identified

- Polypropylene has low impact strength.
- On mixing PP with an elastomer its impact strength is found to increase.
- Tensile strength decreases on mixing with the elastomer.
- With a better elastomer and ternary fiber material we can produce a composite with high strength and tensile properties
- A novel fiber from Darbha plants (Darbha fiber) with excellent tensile properties has been identified to be used as the ternary phase.

# Motivation

- Even though several NFRPs are available for automotive applications, still there is a need of lot of new natural fibers to improve the existing properties
- Despite its presence worldwide the potential of darbha grass fibers has not investigated properly.

# Objectives

- To develop an impact resistant composite material using polypropylene/EPDM/Darbha fiber for automobile applications.
- To analyse the mechanical properties(Impact,Tensile,hardness and Flexural) of the developed composite
- To evaluate the fracture morphology of the developed composite.



# Methodology

1. Collection of raw materials
  - a. Darbha fiber
  - b. Polypropylene
  - c. Ethylene propylene diene monomer
2. Preparation and characterization of Darbha fibers.
  - a. Water retting/chemical retting & fiber extraction
  - b. Fiber functional group identification (FTIR)
3. Blend preparation - Thermal blending using twin screw extruder
4. Fabrication - Injection molding
5. Mechanical testing
  - a. Tensile testing - ASTM D 638
  - b. Impact testing.- ASTM D 256
  - c. Flexural testing - ASTM D 790
  - d. Hardness testing - ASTM D2240
6. Morphological analysis of developed composites-  
Study the fracture morphology using scanning electron microscope (SEM) image





# Materials

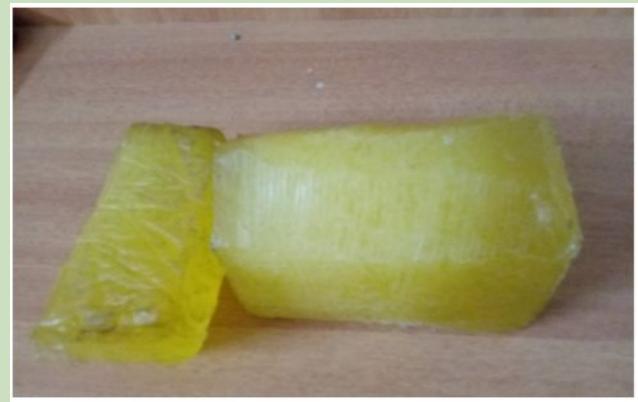
## 1. Raw materials



Darbha grass  
Cellulose content- 70.58%



Polypropylene  
(H350FG)



Ethylene propylene diene monomer  
Keltan 9565Q  
Melting point - 180°C



# Experimental

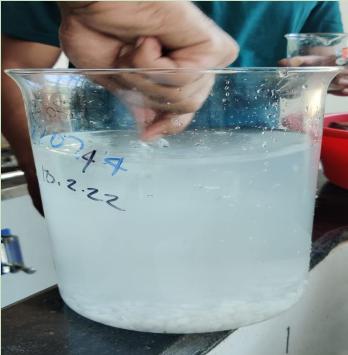
## 2. Fiber Extraction - Chemical retting



Cut the Darbha grass with 20cm in length



The grass was weighed in a weighing machine to obtain 500g which was then placed inside the plastic bowl.



In the chemical retting process, NaOH solution (containing water with 10% NaOH) was created in a 4000 ml beaker



NaOH solution containing 11000 ml of water with 1100 g of NaOH was poured into the plastic bowl having the grass inside it.



So the chemical retting process started at 2:30 pm on 10th March 2022.

Retted Darbha grass after  
24 hours



The darbha fiber was  
separated from the  
NaOH solution



The separated darbha  
fiber is washed  
thoroughly to remove  
remaining NaOH and  
Lignin content.



The washed darbha  
fiber is collected in a  
bowl



It was cutted to medium  
fiber



After 3 days of  
sun-drying



The darbha fiber is  
dried for 3 days

# Fourier Transform Infrared Spectroscopy (FTIR)

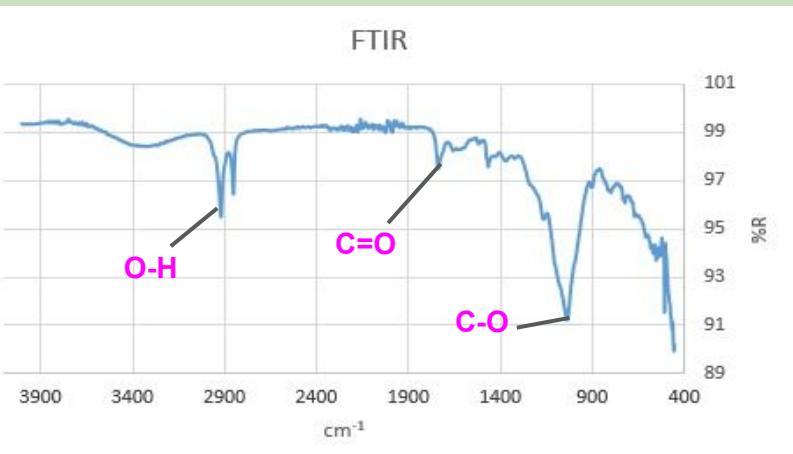


Fig: FTIR Spectrometer

source: <https://www.google.com/url?q=%3Dhttps://www.perkinelmer.com/product/spectrum-two-ft-ir-sptf0-s-w-wtgs-apv-l160000f%26sa%3D%26source%3Ddocs%26ust%3D165376204191557%26usg%3DAOVvaw2pGc3l-iGBF2ceMP5Hdgh&sa=D&source=editors&ust=1653815788509673&usg=AOVvaw3wqwtUvTxj2W7KyDfr6t>

- FTIR is used to identify the functional group present in the fibre.
- FTIR spectra reveal the composition of fibers.
- The most common use is in the identification and characterization of unknown materials and confirmation of production materials.
- The speed of FTIR analysis makes it particularly useful in screening applications.
- It has a testing wavelength range of  $4000\text{-}450\text{ cm}^{-1}$
- Operating range:  $5\text{ - }45\text{ }^{\circ}\text{C}$ .

## DARBHA GRASS



Major functional group Identified

Reflectance frequency range ( $\text{cm}^{-1}$ )

O-H(hydroxyl)

3334.5, 3330.6-2848.79, 3343.3-2849.2

C-H (aromatic compound)

1653.33

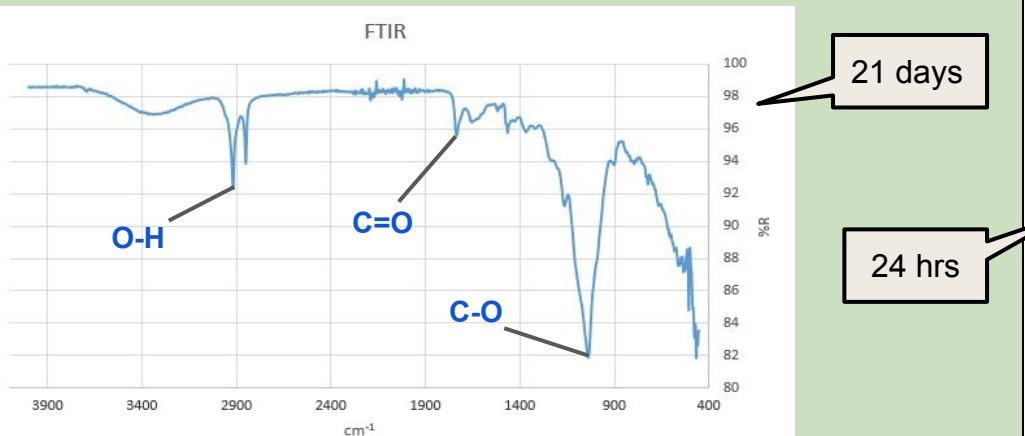
C-O (aryl ether)

1028.61, 1035.06, 1034.5

C=O(aldehyde)

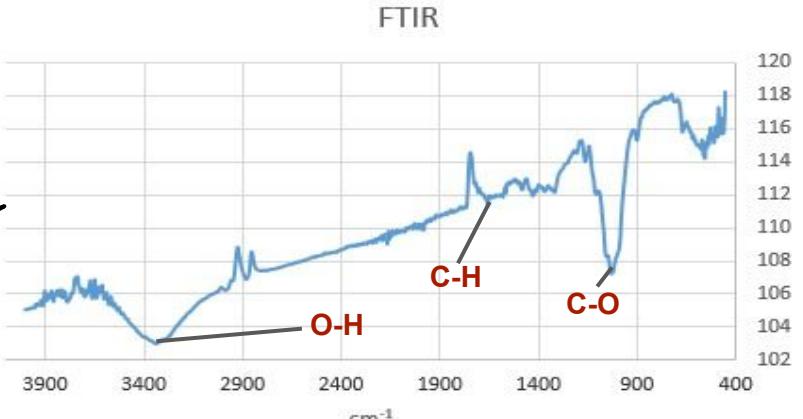
1732.09, 1739.5

## WATER RETTED-DARBHA FIBER



24 hrs

## CHEMICAL RETTED-DARBHA FIBER



### 3. Blend preparation - thermal blending using Twin screw extruder

- Thermal blending of PP/EPDM/Darbha fiber is done using twin screw extruder..
- Before feeding to the extruder, the EPDM block is first cut and rolled through a two roll mill into bands and cut into pellet sized pieces.
- The PP/EPDM was taken in 3:1 ratio and four variation of fiber constituents were taken.

SI No.	PP	EPDM	Darbha	Total
1	375g	125g	25g(5%)	525g
2	375g	125g	50g(10%)	550g
3	375g	125g	75g(15%)	575g
4	375g	125g	100g(20%)	600g

- Each composition is properly mixed and fed manually into the extruder at 180° c and 78 RPM.



## 4. Fabrication - Injection moulding

- Model- OMEGA 80 WIDE
- Most of the PP compounds for automotive applications are made into automotive parts through injection molding
- Injection pressure - 1639 kg/cm<sup>2</sup>  
Injection rate - 133 CC/sec
- Nozzle temperature - 215°C  
Barrel temperature - 220°C
- For our study dumbbell shaped samples are made using injection moulding technique.
- The material is dispensed into the cylinder - melted - injected into the die under pressure.
- After around one minute the part is ejected when the resin is solidified.
- Made a minimum of 15 test samples for each combination( 5%, 10%, 15%, 20%)
- Dimension of the sample- **164x13x3.6mm**





- The materials are thermally blended in a semi solid state and noodle samples are produced which was pelletised using a scrap grinder.
- It was then converted into dumbbells by injection molding techniques.



## 5. Mechanical testing



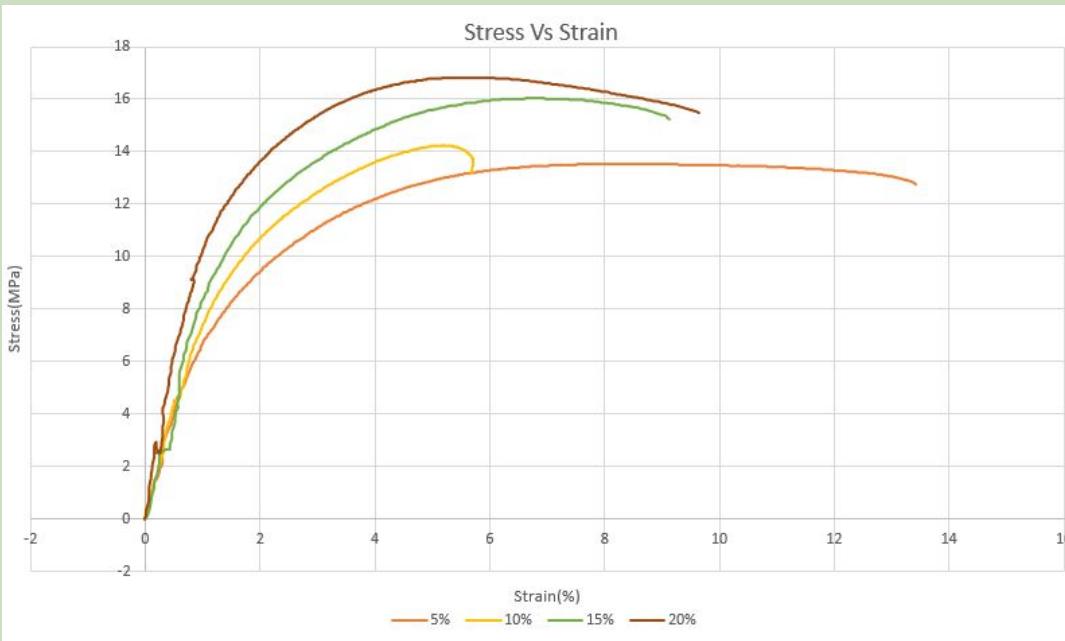
Fig : Universal testing machine

### 1. Tensile testing - ASTM D 638

- It provides information about the tensile strength, yield strength and ductility of materials.
- It measures the force required to break the specimen.
- It provides much information about tensile strain, elongation, tensile modulus and elongation at break.

# RESULTS

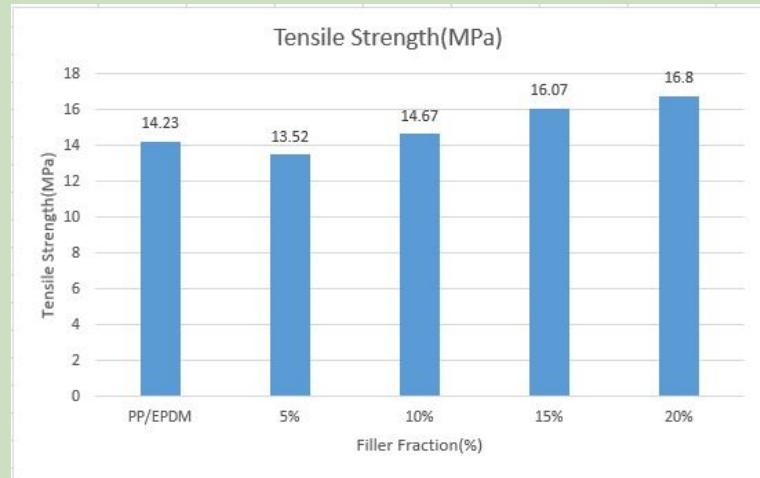
## Stress vs Strain graph



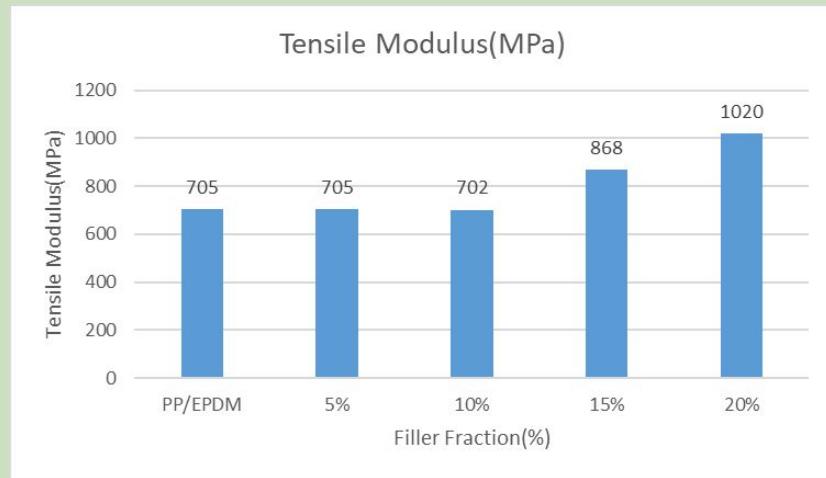
- Stress concentration increase with fiber content
- Area under the stress strain graph gives toughness.
- 5% sample possess the highest toughness
- Fibers inhibit ductile mobility

# RESULTS

## Tensile Strength



## Tensile Modulus



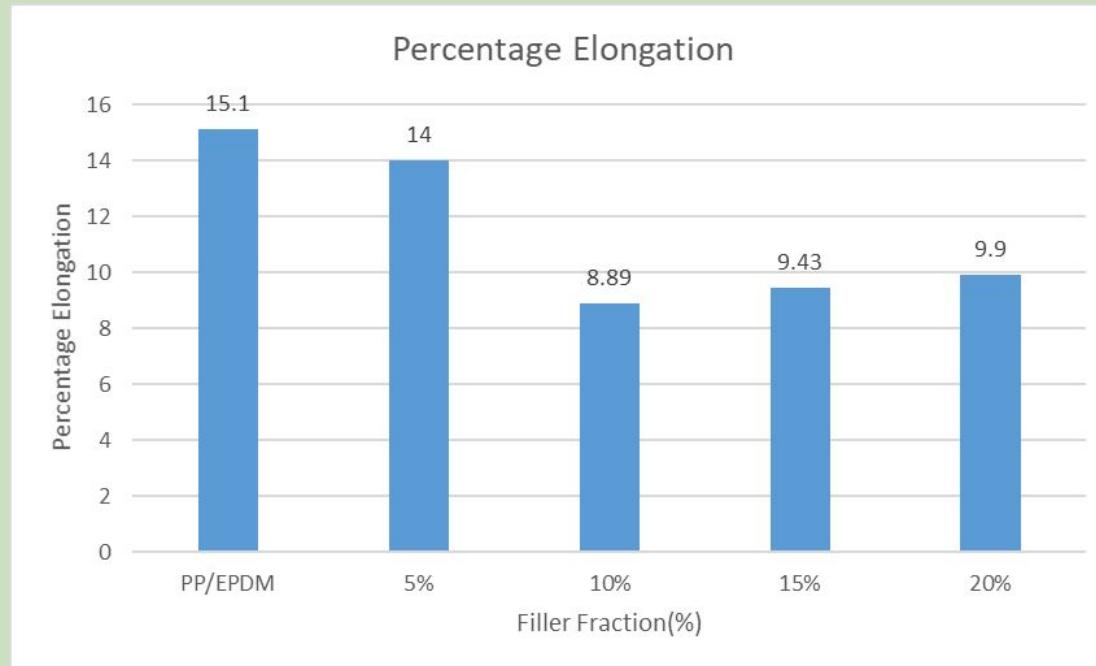
- Increasing fibre decreases voids in the matrix hence tensile strength increases
- Tensile modulus is directly related to the amount of fiber content.





# RESULTS

## Percentage Elongation



## 5. Mechanical testing



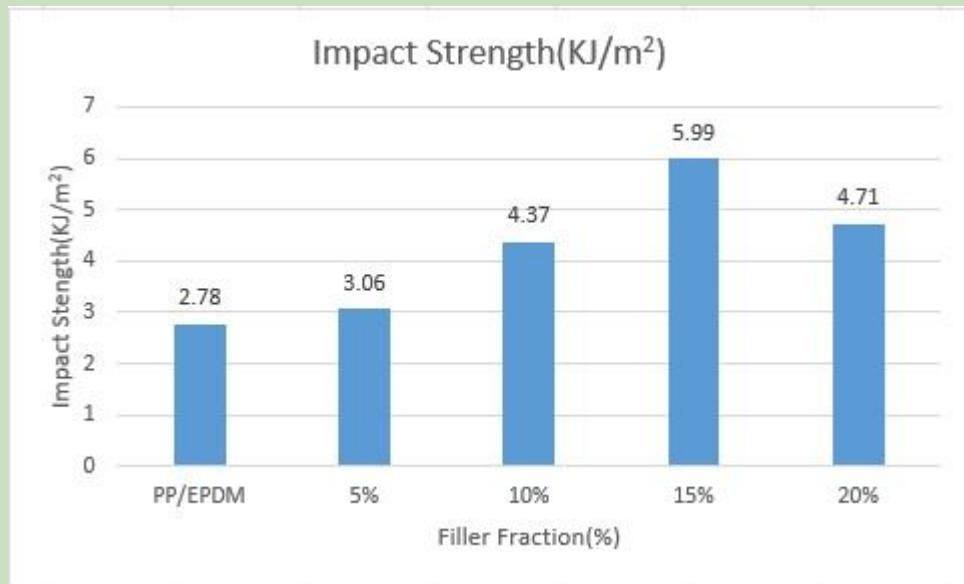
Fig: Impact testing machine

### 2. Impact testing.- ASTM D 256

- Impact test is used to determine how the material responds to a sudden stress act on it.
- It is used to understand properties like toughness, brittleness, impact resistance of material.
- The test specimen types include notch configuration mainly V-notch and U-notch.

# RESULTS

## 2.Impact strength



- Increased fibre loading may result in more energy being used to break the coupling between the interlaced fibre bundles.
- Higher fiber concentration require less energy to crack due to stress concentration.
- Optimum bonding is found in 15% sample

## 5. Mechanical testing

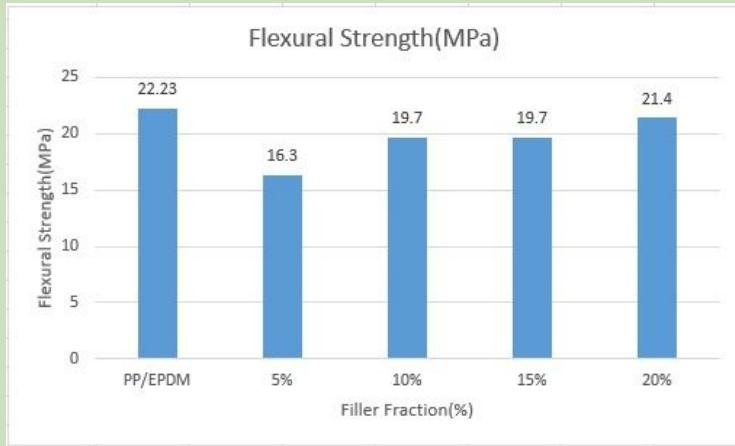
### 3. Flexural testing - ASTM D 790

- Flexural strength also known as modulus of rupture which is the ability to resist deformation under load.
- During flexural test information about flexural strength, flexural stress & flexural strain at break can be obtained.
- Flexural modulus can be also obtained from this test.

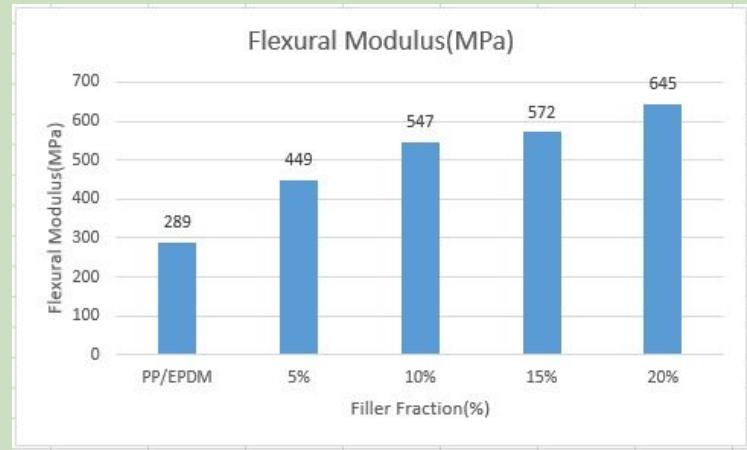


# RESULTS

## Flexural strength



## Flexural Modulus



- An increase in flexural strength & flexural modulus is observed with the incorporation of Darbha fiber to PP/EPDM blend.
- This is mainly due to Dharba fibers increasing the energy absorption under flexural loading conditions.



## 5. Mechanical testing

### 4. Hardness testing - ASTM D 2240

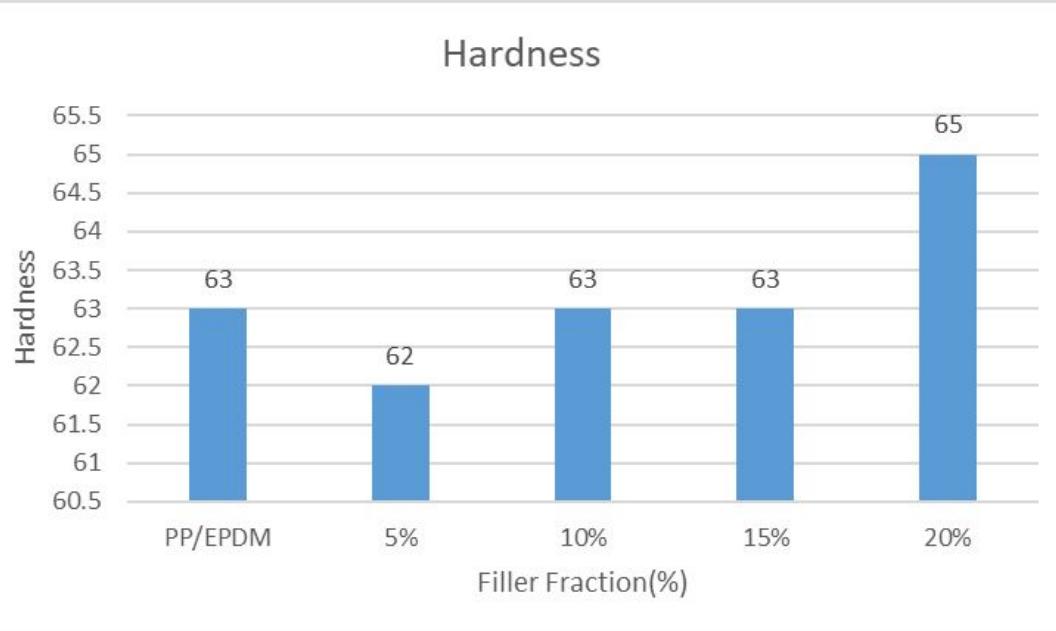
- The hardness of the specimen is measured using Durometer.
- Two types - Shore A and Shore D
- Shore A - hardness of soft materials
- Shore D - hardness of hard materials.
- Type D: Hardened steel rod 1.1 mm – 1.4 mm diameter, with a 30° conical point, 0.1 mm radius tip and force of 4.5 kg.



Source: <https://www.checkline.com/product/AD-100>

# RESULTS

## 4.Hardness



- As fiber content increases hardness also increases

## 7. Scanning Electron Microscopy

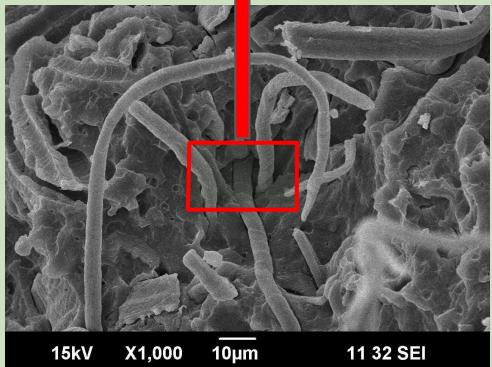
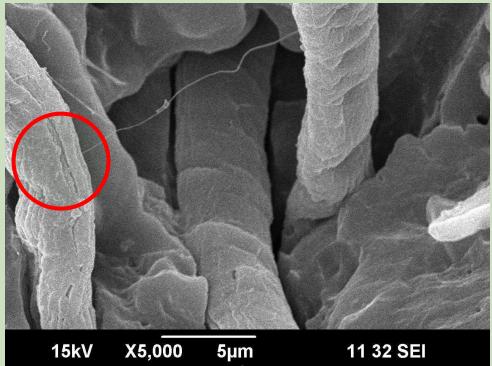


In our study the PP/EPDM specimen with 15% darbha fiber content that showed greater impact value is used for obtaining the SEM images.

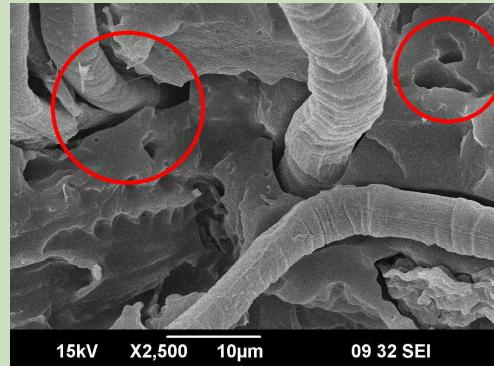
## 5. SEM RESULTS

### 15 % fibre sample

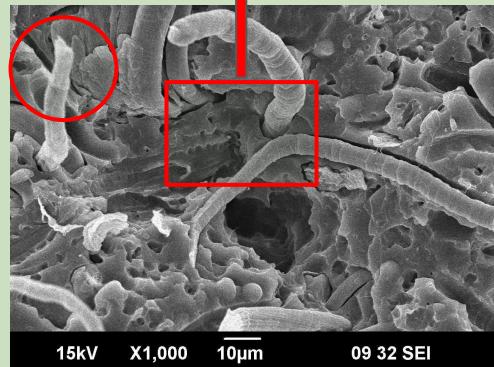
Minimal  
fiber  
cracks



Fiber-matrix  
debonding

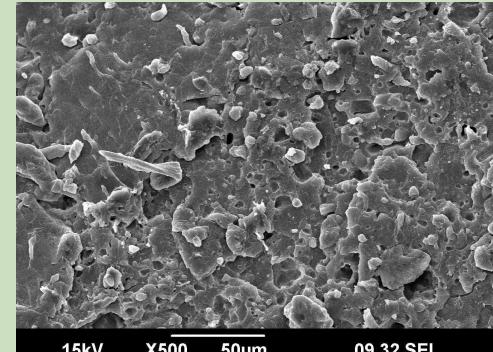
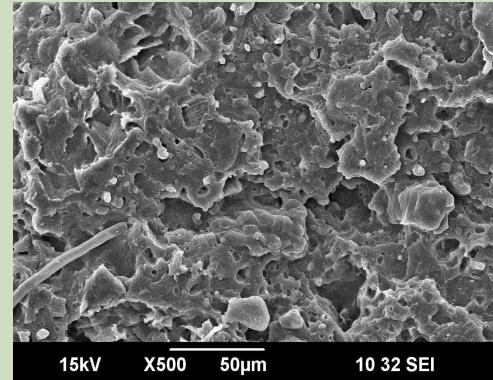


Fiber Fracture



Fiber Pull  
outs

### 5 % fibre sample



- The failure mechanism in fiber reinforced composite due to impact force is mainly because of delamination, intralaminar matrix cracking, longitudinal matrix splitting, fiber-matrix debonding, fiber pullout, and fiber fracture.
- From the Scanning Electron Microscopy(SEM) it is evident that the fracture propagation is mainly due to:
  - Fiber-pull outs
  - Fiber-matrix debonding
- From the above mechanical results, we can see a downward trend in Impact property after 15% of fiber content. This may be due to increase in fiber content increasing the pullouts and debonding.



# Future scope



# Conclusions

- Successful fabrication of the Darbha fiber reinforced thermoplastic elastomeric composite has been done by injection moulding
- The tensile, impact, Hardness and flexural properties are found to increase with increase in fiber content
- It was found from the study that the sample with 15% fiber content showed the highest impact resistance.
- Properties like tensile, impact and flexural strength is found to be greatly affected by void content.
- SEM results shows minor fiber cracks, fiber pullouts and debonding in some regions.
- Possible future work can be carried out by selecting a suitable bonding material.



# Achievements

- Our project has been selected for the project expo conducted in our college.
- Abstract submitted for International Conference on Advanced in Manufacturing and Material science(ICAMMS).



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