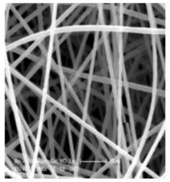
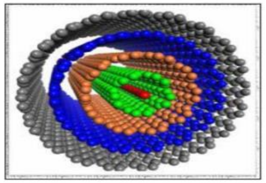
Department of Production Engineering

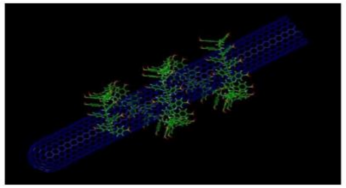
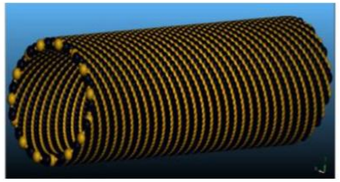
Veermata Jijabai Technological Institute, Mumbai, India 400019

Centre for Advanced Material Research and Innovative Manufacturing (CAMRIM)

PI- Dr. Dattaji K Shinde,

Associate Professor and Head of Production Engineering

Vision

Our vision is to create a Centre for Advanced Materials Research an Innovative Manufacturing (CAMRIM) within the VJTI. As the flagship VJTI, we are obligated to be of value to high-technology firms for Maharashtra State, both in terms of innovation and workforce development. The proposed Centre (CAMRIM) will engage not only with small and medium-sized enterprises (SMEs), but also large corporations across the state and beyond. Existing collaborations between industry and CAMRIM faculty members will be leveraged. VJTI has already invested significant resources into this effort through cluster hires in Centre of Excellence in Mechanical and Electrical Departments and will also be leveraged by CAMRIM to strengthen their efforts. CAMRIM will initially focus on five material thrust areas, i.e., Nanomaterials, composites, lightweight metals nano-structured materials, and electronic materials along with manufacturing innovation, due to the established strengths of existing faculty members in materials synthesis, characterization, modelling, and manufacturing. While these five materials systems are unique, there are synergies that can be exploited around the physical characterization; numerical and analytical modelling; and advanced manufacturing techniques. These efforts will enable new innovations and advancements in technologies.

Centre Goals

The goals of CARMMI will be to:

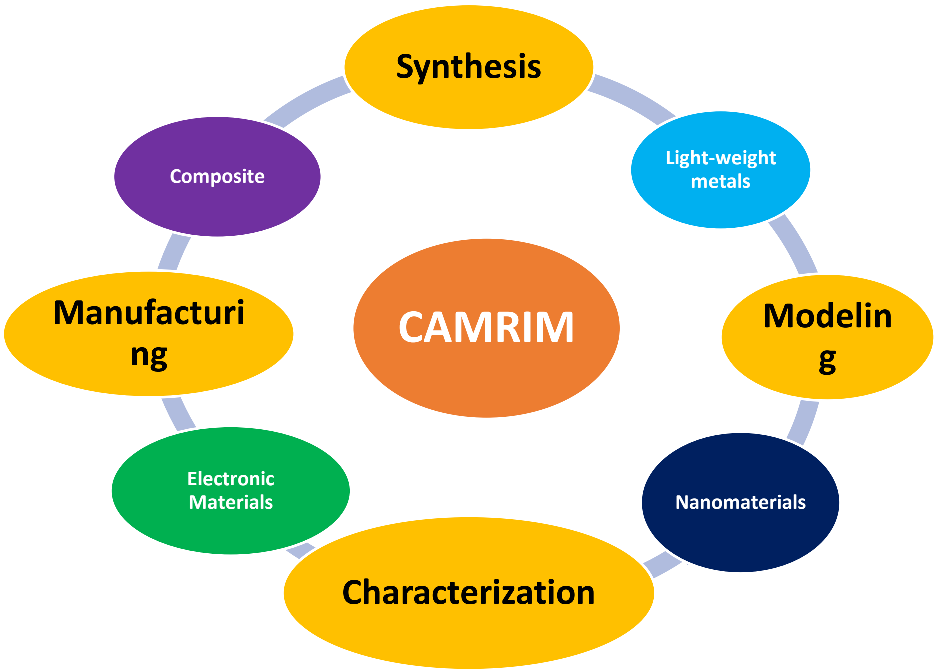


Fig. 1 Concept of Centre for Advanced Material Research and Manufacturing Innovations

- Develop advanced materials and manufacturing innovations through fundamental and applied R&D efforts.
- Collaborate with local, national, and international companies and universities to enable such innovations through research projects (supported by public, private and industrial funds) and shared facilities.
- Educate the next generation of researchers, scientists, and engineers who will assure the next technological innovations are developed and manufactured in the India particularly Maharashtra state.
- Engage with other entities such as Department for skill development, Resources and Economic Development, the Maharashtra Higher Technical Education, the Maharashtra Manufacturing Extension Partnership, and the Polytechnic and ITI to assure the research and educational objectives are achieved.

Centre Objectives

The objectives are to be a source of information about materials, processes and manufacturing technologies.

- ✓ To provide high quality education programs in Post-graduation and PhD in advanced materials science and manufacturing technology.
- ✓ To conduct seminars, conferences and other educational activities related to advanced materials and Manufacturing as well as applications.
- ✓ To promote faculty collaborations across institutes, industries.
- ✓ To develop the additive manufacturing scalable industrial set up using nanomaterials
- ✓ Synthesis, characterization and application of five materials thrust areas:
  - Nanomaterials (Nanofibers, CNT's, Nanoparticles, Nanowires etc.)
  - Composites
  - Lightweight metals,
  - Nano-structural materials,
  - Electronic materials.
  - Smart materials
- ✓ Design and Fabrication of Nanoengineered Hybrid composite for structural application

Fig 2. Application of nanofibers

Infrastructure and Resources

CAMRMI at VJTI will require space, high-end research equipment and skilled research faculty. As impact of TEQIP-I and II have already created many faculties with Ph D in emerging research domain of engineering and technology and initiated research in the direction of further development of the current research. The following is the list of faculty involvement in the development of CAMRMI including International advisory faculty are shown in Table 1.

List of Faculty

Table 1 List of Faculty from VJTI and International Advisory Faculty

Sr. No	Name of Faculty	Designation	Area of research
1	Dr. D K Shinde -PI	Associate Professor	Nanoengineering/Nanotechnology
2	Dr. S P Borkar	Professor	Textile Composite Materials
3	Dr. D N Raut Co-PI	Professor	Advanced Manufacturing and CAD/CAM
4	Dr. V B Suryawanshi	Assistant Professor	Nanoengineering/ Nanotechnology
5	Dr. W S Rathod	Assistant Professor	Material Science and Engineering
6	Dr. A S Rao	Assistant Professor	Additive Manufacturing
7	Dr. D S Wahval	Professor	Nanotechnology
8	Dr. N N Wankhede	Lecture Professor	Chemistry of Nanomaterials
10	Dr. A N Bambole	Professor	Structural Engineering

11	Dr. S Y Mhaske	Associate professor	Geospatial Technology
12	Dr. S A Mastud	Associate professor	Manufacturing Engineering

Table 2 List of Faculty from VJTI and International Advisory Faculty

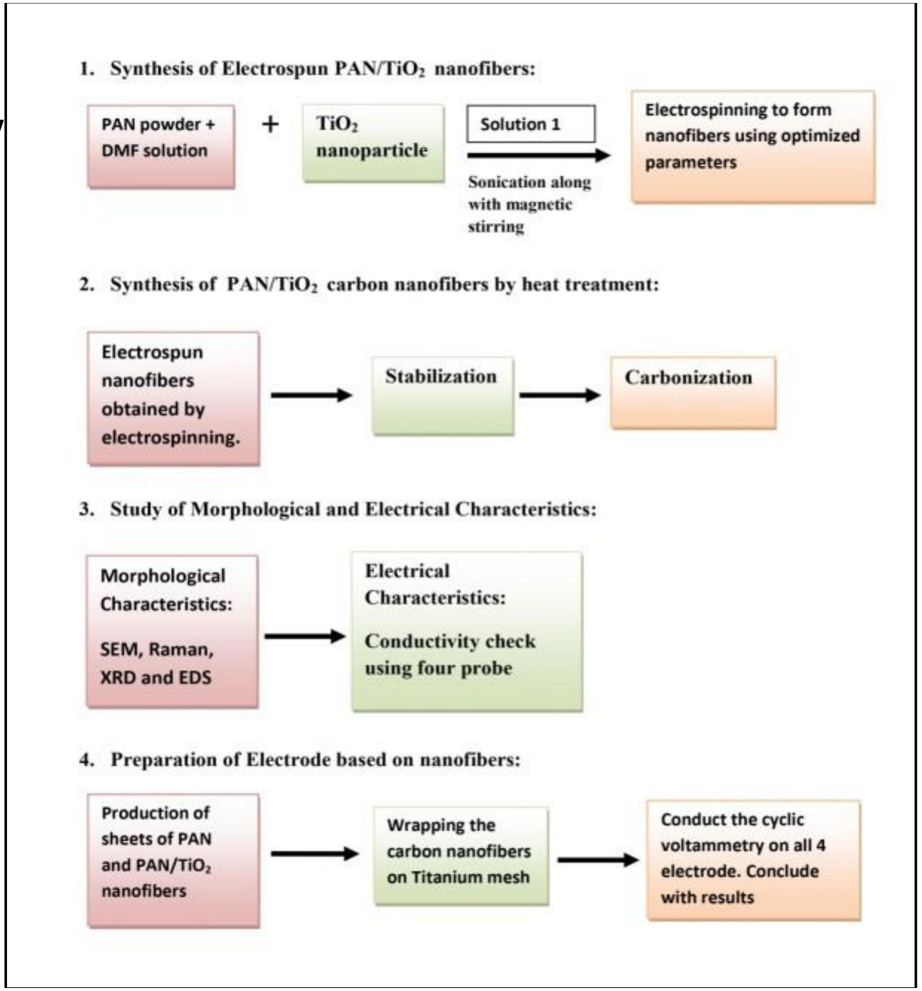
International Faculty Advisory			
1	Dr. Ajit D Kelkar	Professor and Chairperson of Nanoengineering JSNN North Carolina A and T State University NC USA	Atomistic Modeling , Nano Engineered Materials, Eletrospinning, Molecular Dynamic Simulations, Nanotechnology, Multifunctional Materials, Crashworthiness, Low Cost Composite Manufacturing (VARTM Processing), Mechanical Characterization of Materials including Metals, Polymeric Composites (Tape and Textile), Ceramics and Ceramic Composites, Computer Aided Design and Modeling, Finite Element and Finite Difference Modeling, Numerical Analysis, Fatigue and Impact Modeling and Testing of Polymeric Composites, Ceramic Composites, Textile Composites, Micromechanics Modeling and Testing, Single Fiber Modeling and Testing
2	Dr. Ram Mohan	Professor Nanoengineering JSNN North Carolina A and T State University NC USA	Computational multi-physics/multi-scale modeling and simulation in engineering and physical applications; computational mechanics, nanomechanics, and material sciences; processing, mechanics, characterization, and computational modeling of multi-scale composite and nanoengineered material systems
3	Dr. Shyam Arvamudhan	Assistant Professor Nanoengineering JSNN North Carolina A and T State University NC USA	NanobioelectronicsMicrosystems and Nanotechnology Tools for Disease Diagnostics and Regenerative Medicine, Structure-property relationship in nanostructures., Neural Interfaces, 3D system integration
5	Dr. Lifeng Zhang	Professor Nanoengineering JSNN North Carolina A and T State University NC USA	Advanced nanomaterials including polymer, ceramic and carbon nanofibrous materials and their nanocomposites
6	Dr. Salil Desai	Associate Professor Industrial System Engineering North	Hybrid Nano/Micro and Bio Manufacturing Tissue Engineering & Drug Delivery Multiscale and Multiphysics modeling Manufacturing Systems Product Design and Realization Electronic and Energy Devices CAD/CAM Combinatorial Additive Manufacturing

		Carolina A and T State University NC USA	
7	Dr. Jitendra Tate	Associate Professor of Manufacturing Engineering at Texas State University-San Marcos TX, USA	Development, manufacturing; and characterization of high-performance thermoset and thermoplastics polymeric matrix composites for industrial, aerospace, sports , biomedical, and energy applications
8	Dr. Mahendra Samayakano	Assistant Professor Mechanical Engineering University Malaysia PahangMalaysia 26600	Nanotechnology, MEMS, Manufacturing and Material, Quality Management, DFMA, Mechanical Design, Applied and Computational Mechanics
9	Dr. Asim Tewari	Professor Mechanical Department IIT Bombay	Multi-scale multi-physics material modeling, Prediction of fracture using continuum damage mechanics in drawing, extrusion, rolling, forging, dee, Microtexturing on metals, polymers and semiconducting surfaces through Laser processes and using CVD, Solidification processing, Image Reconstruction in Tomography, Finite element modeling, Computer Aided Design and Manufacturing, Sheet Metal Forming, Materials Model development, Machining of advanced materials, Joining, Additive Manufacturing, Numerical Modeling, Melting and solidification
10	Dr. Rakesh Mote	Assistant Professor Mechanical Department IIT Bombay	Focused Ion Beam (FIB) and Laser based micro/nano-fabrication, Plasmonics for sensing and beam manipulation, Ultra precision machining (UPM) processes, Non-conventional machining processes, Machining of advanced materials
11	Dr. Neeraj Kumbhakarna	Assistant Professor Mechanical Department IIT Bombay	TFE, Combustion Visualization and Optical Diagnostics, Computational fluid dynamics and heat transfer, Thermodynamics, Combustion of Energetic Materials (Propellants and Explosives), Molecular Modeling and Simulations, Chemical Kinetics and Reaction Mechanism Development
12	Dr Prof.Dr. Nadir Ayrilmis	Department of Wood Mechanics and Technology, Faculty of Forestry, Istanbul University - Cerrahpasa	Wood Composite Research Engineer, Wood Mechanics and Technology, Polymeric composite 3D printing manufacturing

		Bahcekoy, Sariyer, 34473, Istanbul, Turkey	

- **CAMRIM Centre Equipment and facility -State of Art: Current Research**
  Electrospinning of Carbon Nanofibers facility

Research Methodology



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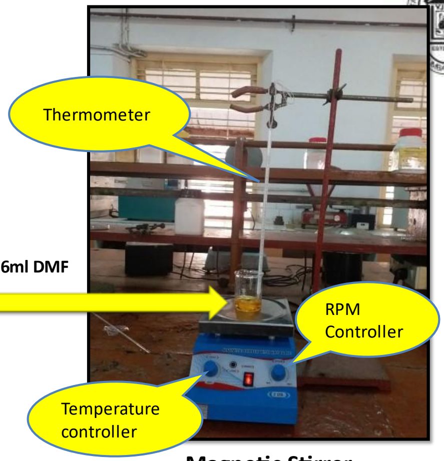
2.4gm PAN + 45.6ml DMF



The solutions was stirred (900 rpm) at 60 °C for 6 hours, then cooling at room temperature before using for electrospinning

Magnetic Stirrer

Viscosity measurement of solution

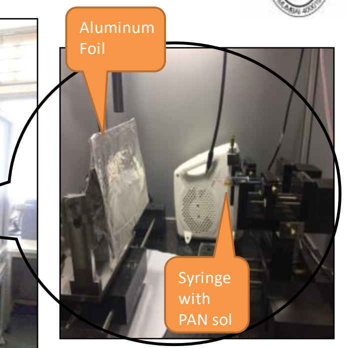

Fungilab Spain Viscometer

Model No :- Viscolead One
Spindle No :- L4(Biggest One) in small sample adapter
Torque :- 64.1 %
RPM :- 50

Average of 10 viscosity readings was taken and the viscosity of the solution was found out to be 76.6 centipoise.

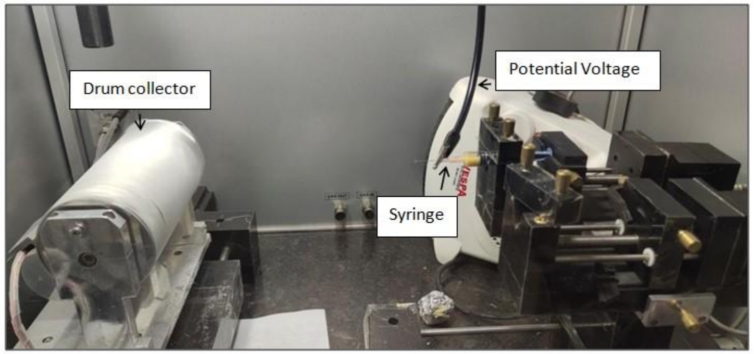
Synthesis of PAN fibers using E - spin Nanotech

Electro-spinning setup

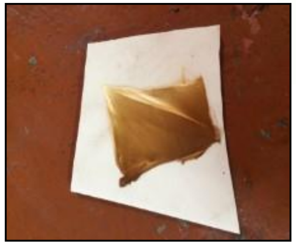


Flat plate collector setup

E-spin using drum collector



Muffle furnace for stabilization



Stabilized fibers of flat plate collector

Stabilized fibers of drum plate collector.

After stabilization, the fibers are kept for a dwell period of 1 hour.

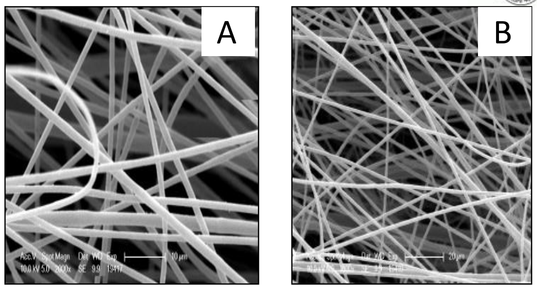
❖ Carbonization:

The carbonization is performed using Nitrogen gas in chemical vapor deposition (CVD) equipment

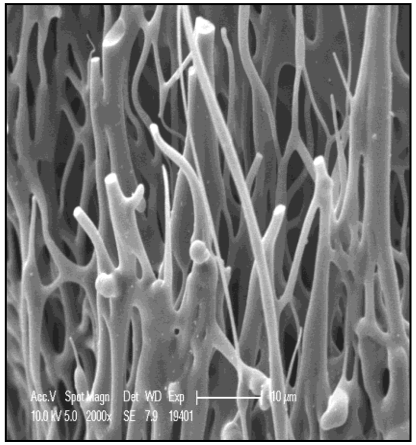
CVD furnace for carbonization

Chemical vapor deposition equipments

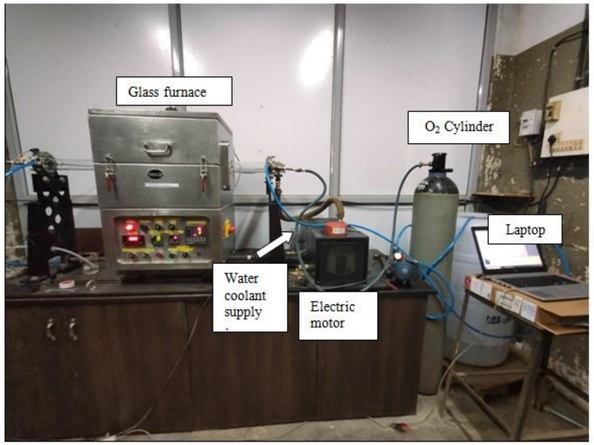
SEM images



SEM Images of Electrospun PAN nanofibers (A) at 2000X resolution and (B) at 1200X resolution using rotating drum collector



2. Carbonization: After Stabilization, carbonization was performed in ChemicalVapour deposition (CVD) in presence of nitrogen gas.



Chemical Vapor deposition setup

The nitrogen gas was supplied at the rate of 80ml/min and temperature was increased to 700°C at the rate of 7°C per min and hold for 1 hour at peak temperature as shown in Figure. The fibers were cool down to RT

After Carbonization

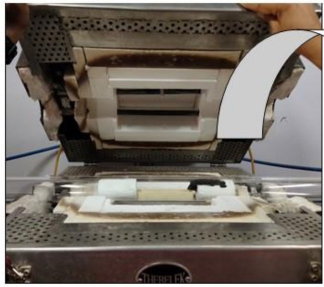
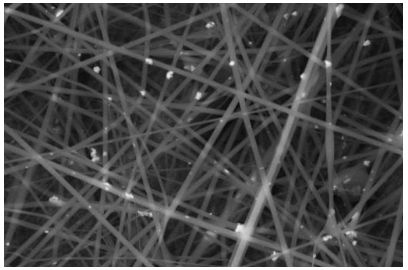


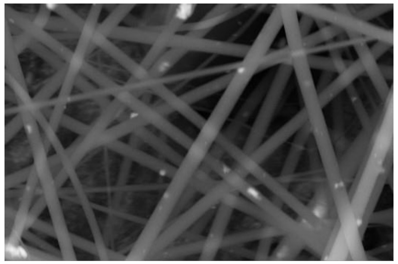
Figure 16: Fibers placed in tube of furnace

Figure 17: Carbonized fibers of PAN/TiO_2 nanofibers

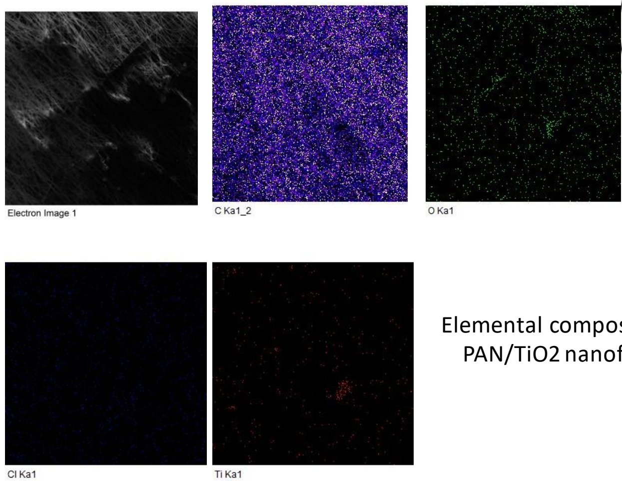
4. SEM images of 10% PAN 1.5% TiO2 wt/wt electrospun nanofibers:



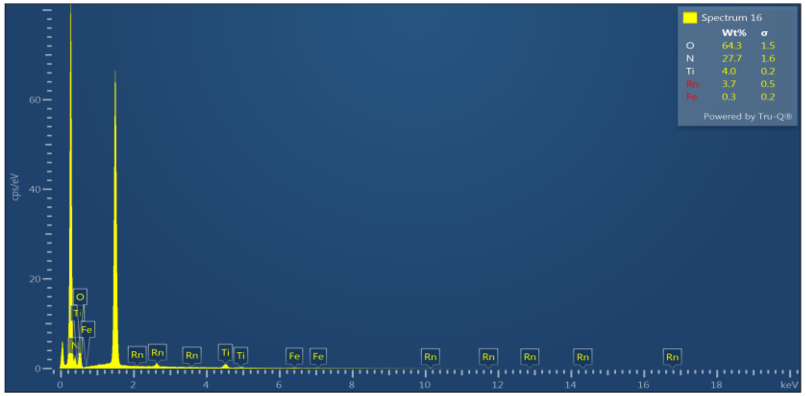
SEM Images at resolution of 2000X



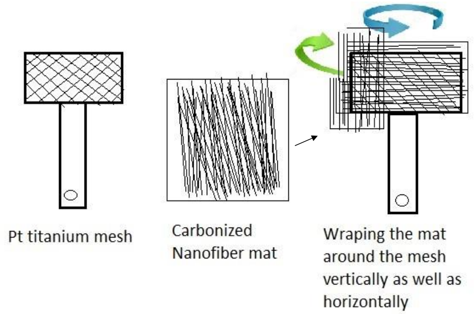
SEM Images at resolution of 1500X



Elemental composition in PAN/TiO2 nanofibers

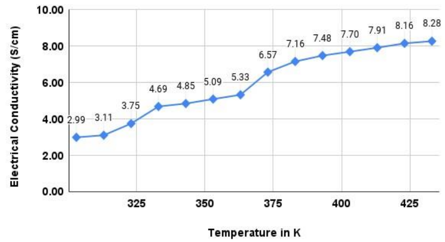


Development of electrode using PAN/TiO2 nanofibers for energy storage application.

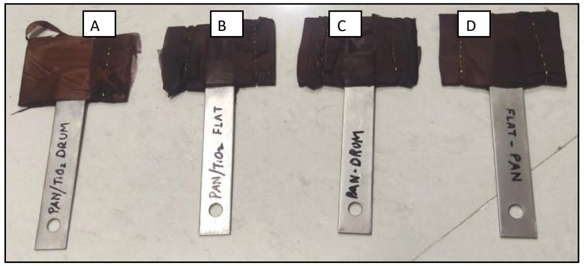


Schematic diagram to prepare electrode [8]

Correlation between Conductivity and temperature of PAN/TiO_2 nanofibers

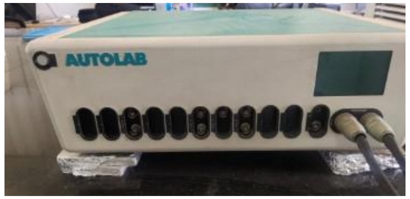


Samples

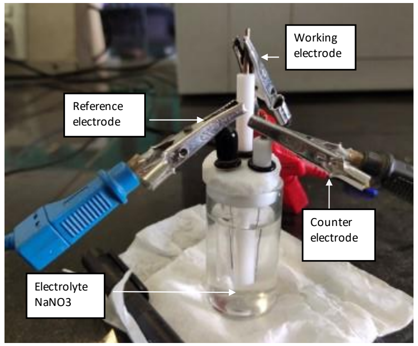


Samples of nanofibers wounded electrode around the titanium mesh for A) PAN/TiO_2 by Drum type B) PAN/TiO_2 by Flat plate type C) PAN by Drum type and D) PAN by Flat type

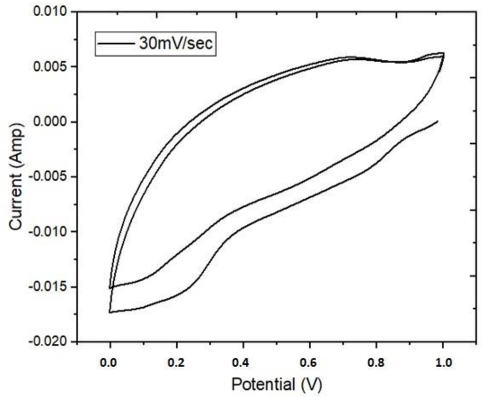
Cyclic Voltammetry for 10% PAN/1% TiO_2 nanofibers



Autolab controller of CV setup



Three electrode setup with working, reference and counter electrode



Equipments Procured

Universal testing Machine of 100 kN with main frame, grips, load cell and extensometer for CAMRMI at Process Lab

- **Aim:** Mechanical Testing of material for Material characterization
- **Objective:**
- Tensile, bending and shear testing with ASTM, IS, and ISI standard for glass, carbon and polymers and metals.
- Obtain high quality data for further fracture analysis
- Validate the simulation data for various material results during application.
- **Impact:**
- UG, PG and Ph D students of all departments can utilize this UTM machine for further material research in composite, energy, medical application and will produce the high quality journal papers.
- This is modern state of art facility for VJTI for materials manufacturing and research

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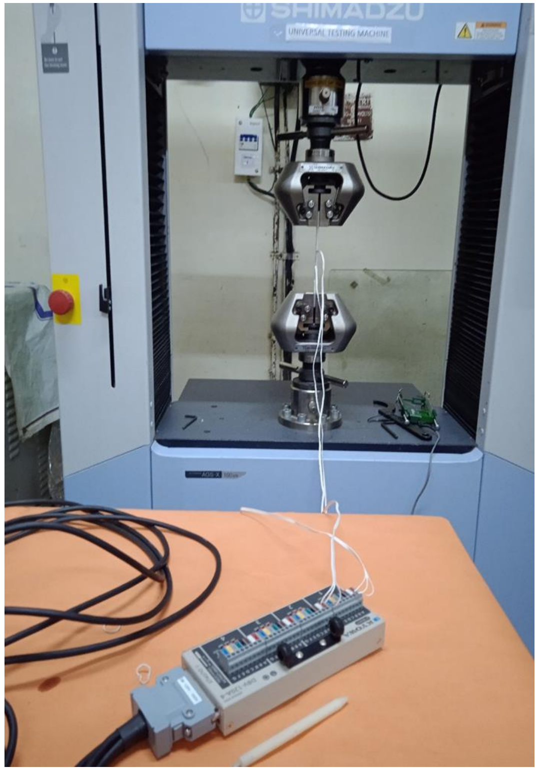
Mechanical Characteriztion of material and testing facilities are as follows.

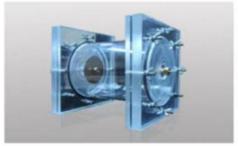


VJTI Material Testing Setup-100kN Shimazdu Machine UTM

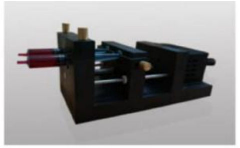
Equipments Procured

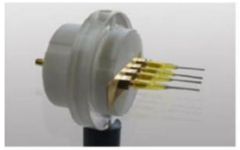
Electrospinning Unit Machine setup for CAMRMI Metrology Lab

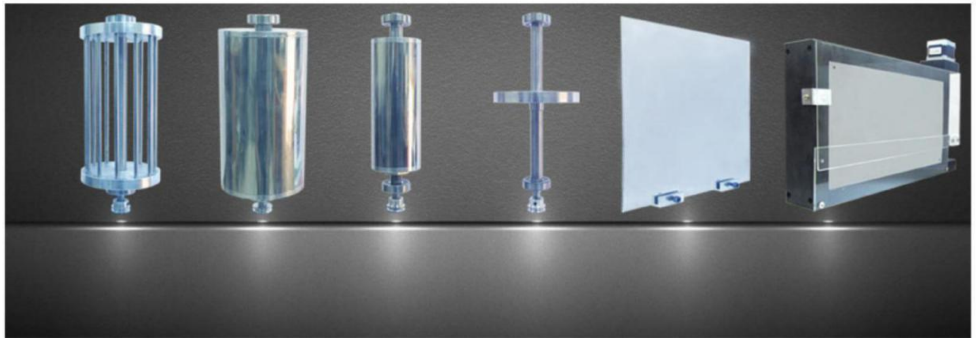
- **Aim:** To produce the nanoscale fibers of diameter of range of 100nm to 400nm
- **Objective:**
- Produce high quality nanofibers of glass, carbon and polymers
- Control the and optimize the quality parameter
- Scale up the nanofiber manufacturing at mass production
- **Outcomes**
- UG, PG and Ph D students of All department can utilize this electrospinning equipment to produce the nanofibers and use this fiber for further research in composite, energy, medical application and will produce thehigh qualityjournal papers.
- This facility of electrospinning will have the state of art facility for VJTI and state incubationcentre for nanofiber manufacturing and research




E-SPIN NANOTECH
NANOFIBER UNIT
ELECTROSPINNING







Testing setup for at VJTI

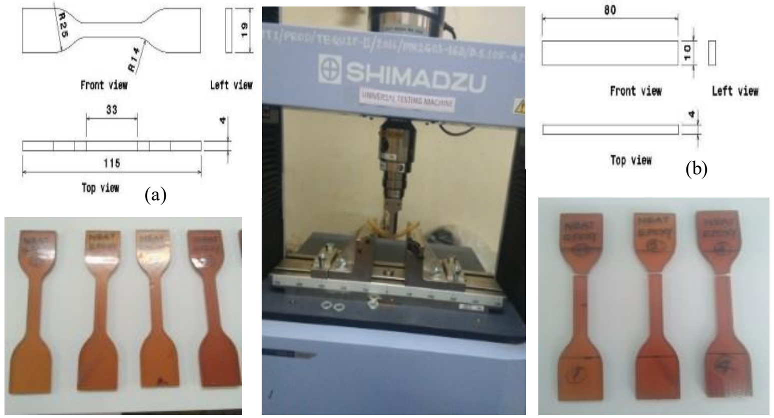
Tensile specimens for PR Test

Specimen ready with Strain Gauge

PR Test DAS with Shimadzu

KOYO Screen for PR Test

Testing of neat epoxy samples



(c) (d) (e)

(a) Tensile test specimen as per ASTM D638 standard (b) Flexural test specimen as per ISO 178 standard (c) Tensile test specimen (d)Universal Testing Machine (e) Tested specimens

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- **Composites Fabrictaion Equipment -Sonicators and Open Mould Vacumm Bagging Method**

VARTM Composite Manufacturing setup

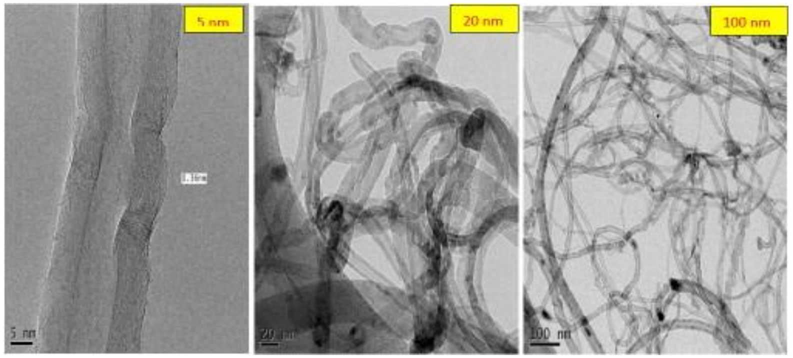
Equipments Procured

Industrial Oven Electric

- **Aim:** Curing of polymeric composite and sintering of material
- **Objective:**
- Study of curing temperature and effect of voids formation
- Optimization of processing temperature for better mechanical properties
- Study Out of autoclave manufacturing of fiberglass polymeric composites
- **Outcomes**
- This facility ofIndustrial Oven Electric Electric Industrial ovenunit will have the state of art facility for VJTI and state incubation centre for composite manufacturing and research.
- This oven has applications from drying, heating, annealing all materials to all laboratories

- **Polymer Nanocomposites Characterization Experimentation**

Properties of Multi-walled Carbon Nanotubes(MWCNTs) Cont..



TEM image of multi-walled carbon nanotubes at different scale

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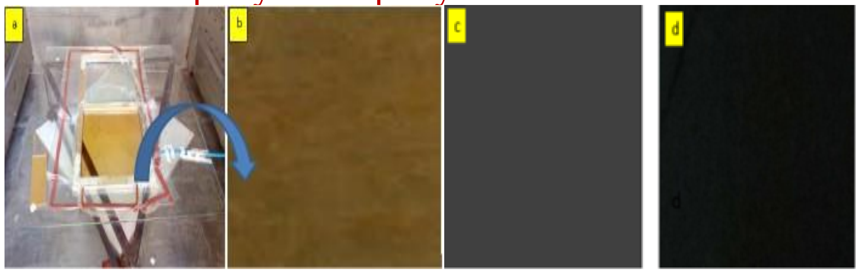
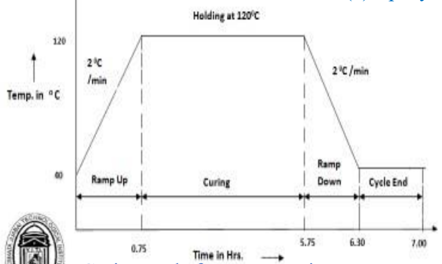
Neat Epoxy and Epoxy with MWCNTs Sheets



(a) Set up for curing of neat epoxy; (b) Cured neat epoxy sheet (c) Epoxy with 0.1% MWCNTs,(d) Epoxy with 0.2% MWCNTs



Curing cycle for epoxy resin

Neat epoxy sample (4 mm) formed on glass (Epofine 281)

Curing is done by raising temp up to 120°C in 30 min. with a rate of 2°C/min, kept at this temp for 5 hours and furnace cooling. Total curing cycle time approximate 7 hours

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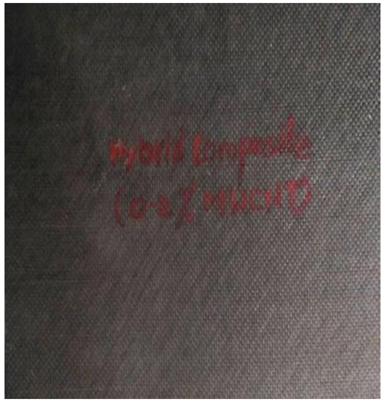
Preparation and testing of neat epoxy sample

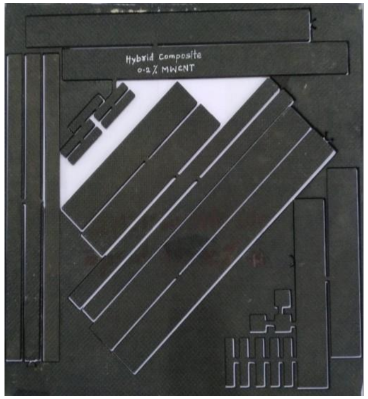
VARTM set up developed in process lab

Curing In Oven at 120 ^{0}C

Hybrid Nanocomposites with 0.2% MWCNTs

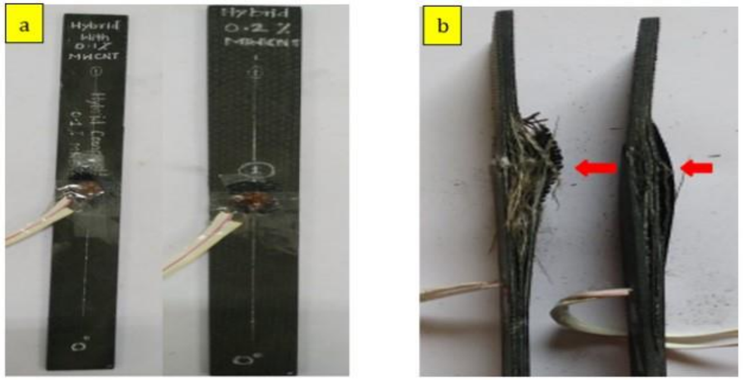


Nanocomposite sheet



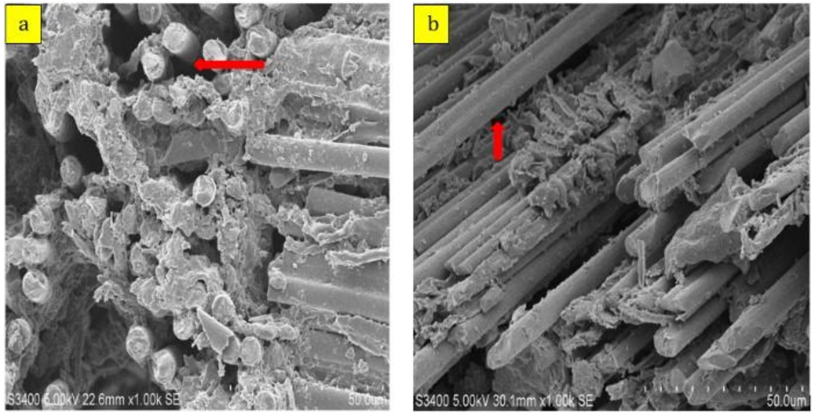
Specimens cut by waterjet machine

Tensile Test-Failure Modes of Hybrid Nanocomposite - 0° Fiber Orientation



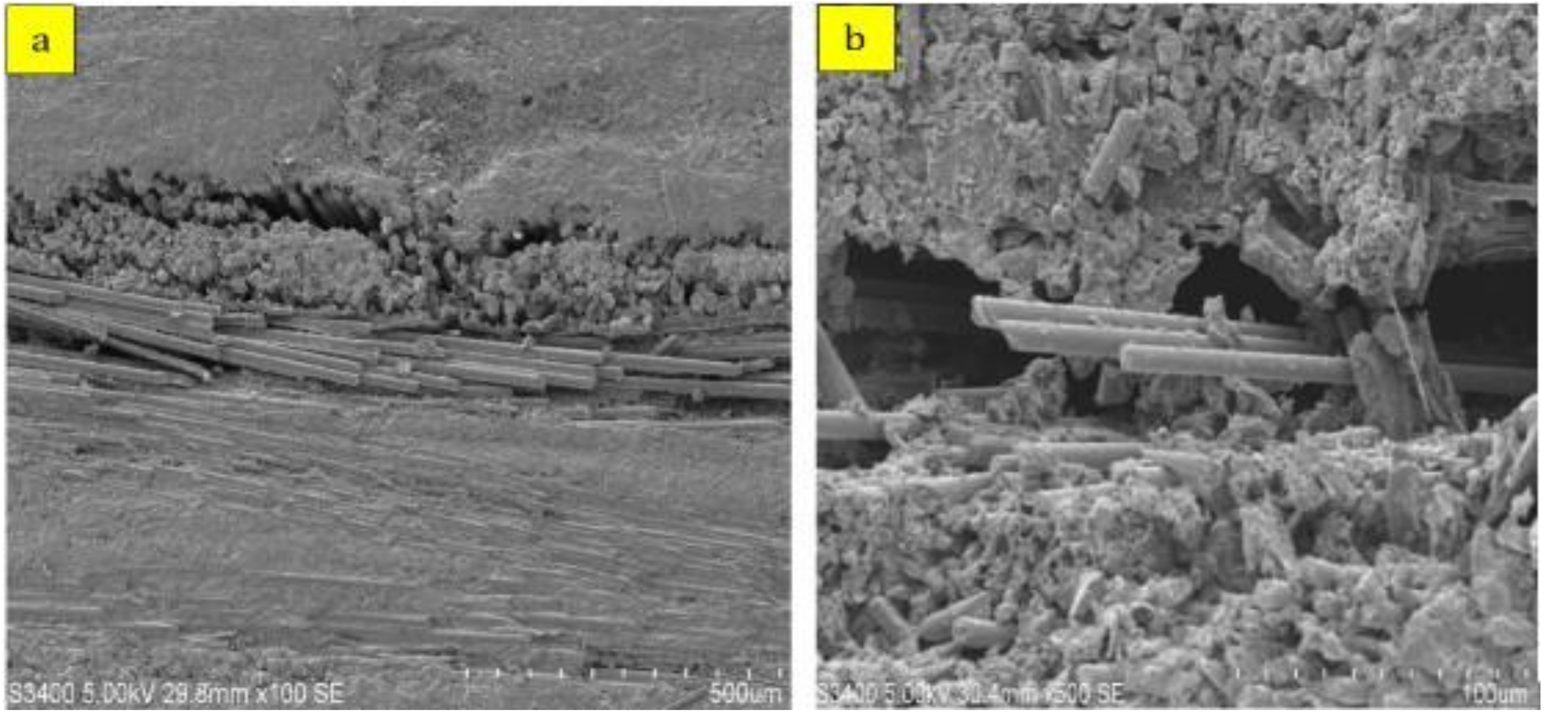
Photograph of tensile test specimens of hybrid nanocomposite for fill direction 0 °
(a) Before testing, (b) After testing

Flexural Test-Failure Modes of Hybrid Nanocomposite - 0° Fiber Orientation Cont…



SEM images of 0 ° fiber oriented flexural specimen of hybrid nanocomposites with
(a) 0.1% MWCNTs; (b) 0.2% MWCNTs.

Morphological Characterization of Tensile Test Specimen of Hybrid Nanocomposites



SEM images of 0˚fiber oriented tensile specimen of hybrid nanocomposites with (a) 0.1% MWCNTs; (b) 0.2% MWCNTs.

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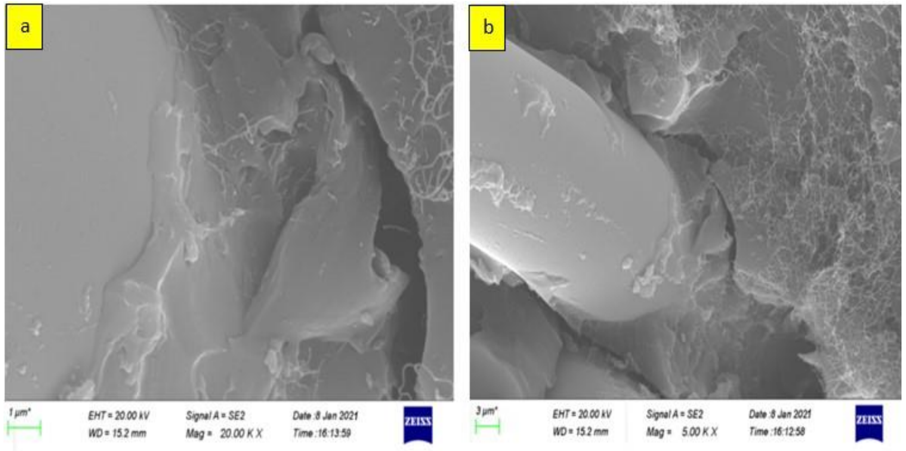
Morphological Characterization of Tensile Test Specimen of Hybrid Nanocomposites



SEM images of fracture surface of hybrid nanocomposites specimen with (a) 0.1% MWCNTs; (b) 0.2% MWCNTs.

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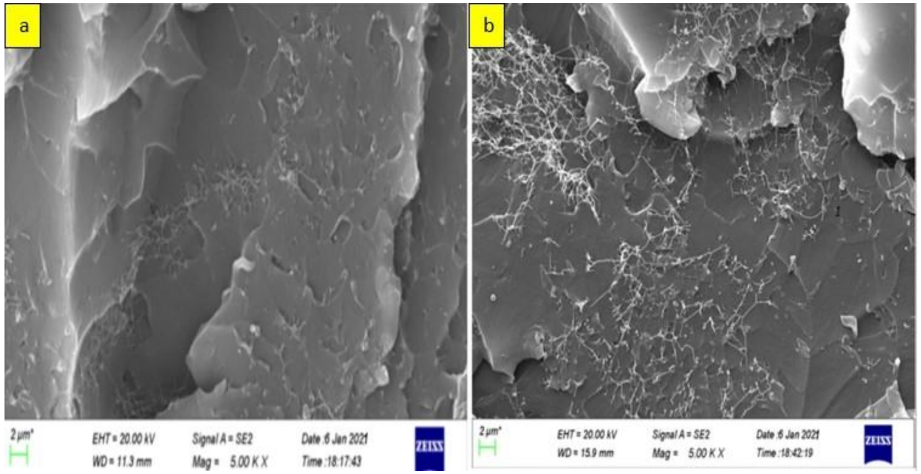
Morphological Characterization of Polymer Nanocomposites



SEM images of polymer nanocomposite (a) with 0.1% MWCNTs, (b) with 0.2% MWCNTs

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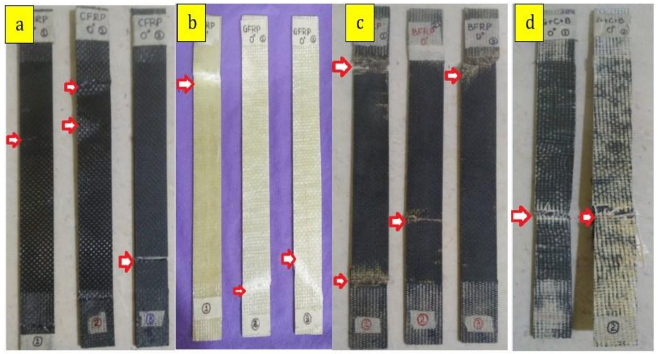
Failure Modes of Composites in Tensile Test



Failure modes of specimens for fill direction 0 °(a) CFRPC; (b) GFRPC; (c) BFRPC, (d) Fiber reinforced hybrid composite

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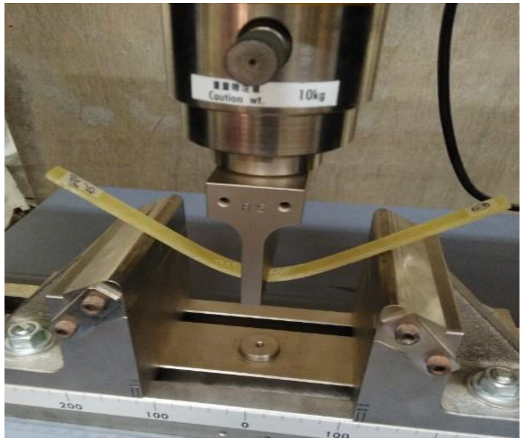
Flexural Test Setup



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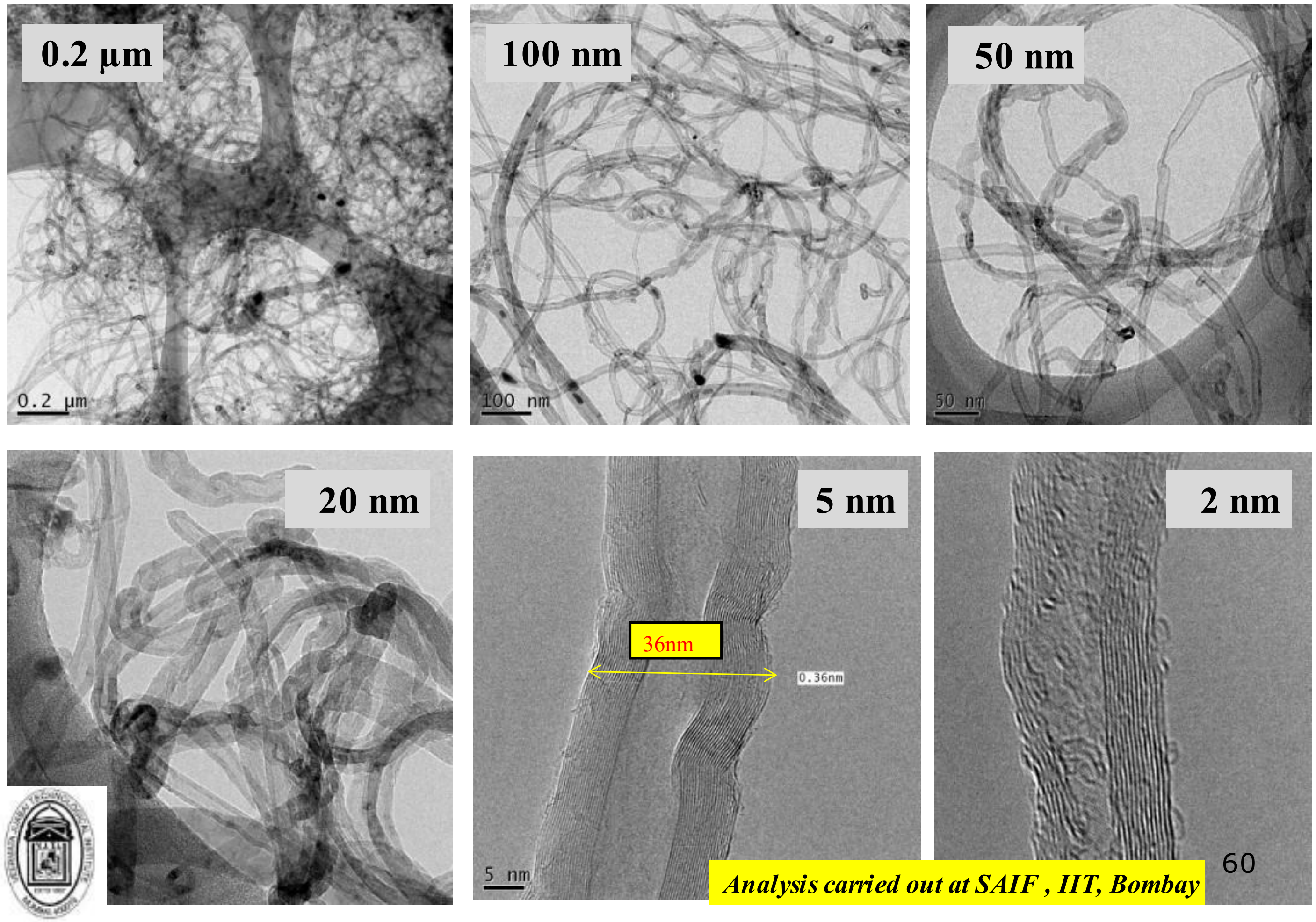
- **Synthesis of Carbon Nanotunes equipment setup**

TEM Images of MWCNT Powder



-

CVD facility at VJTI

	Rate	Time	Temp	Dwell
Stablization	5 degree cel per min	50 min	250	2 Hrs
Carbonization	7 degree cel per min	100 min	700	1 Hr
	7 degree cel per min	158 min	1100	1 Hr

• Addivtive Manufacturing of Polymeric Nanocomposite

Additive Manufacturing / 3D Printing

- A manufacturing by deposition of material in the form of successive layer by layer
- Using Bottom up to Top up manufacturing approach
- 3D Printing – A Thermoplastic Extrusion - Fused Deposition Modeling (FDM)

3D Printer
Accucraft i250D By Divide by zero, Setup at V.J.T.I. CAMRIM Lab, Prod. Engg. Dept.

3D Filament manufacturing by Extrusion

Natural ABS

Weighing of MWCNTs 0.3%

NABS + MWCNT Powder

NABS + MWCNT – after mixing

Heating raw material before extrusion

Extrusion line setup

Courtesy: Solidspace Technology LLP, MIDC Nashik

3D Printing customized Filament ready to 3D Print

Natural ABS Filament

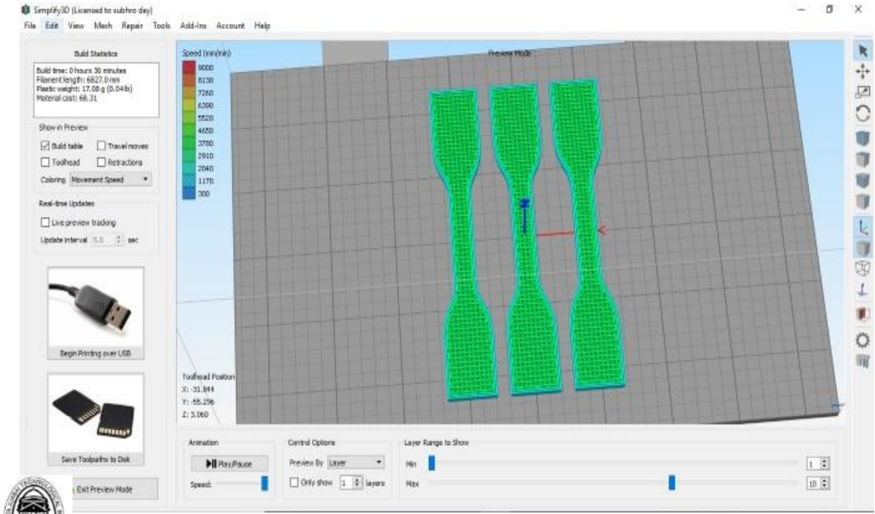
3D Printed Tension test specimen as per ASTM D638 standard

3D Printed Flexural test specimen as per ISO 178 standard

Courtesy: Solidspace Technology LLP, MIDC Nashik

G-code generation for different In-fill Patterns

Software – Simplify 3D



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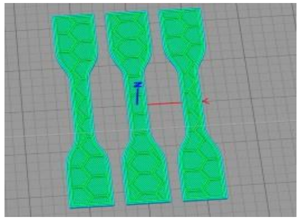
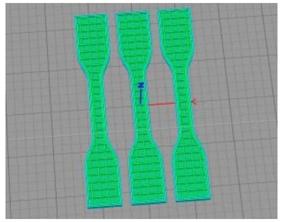
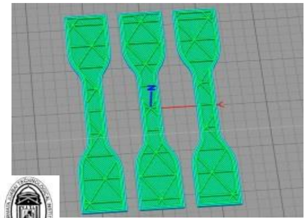
Selected different In-fill Patterns – In-fill 20%



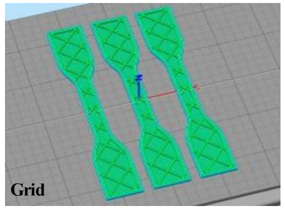
Full Honeycomb



Rectilinear



Triangular



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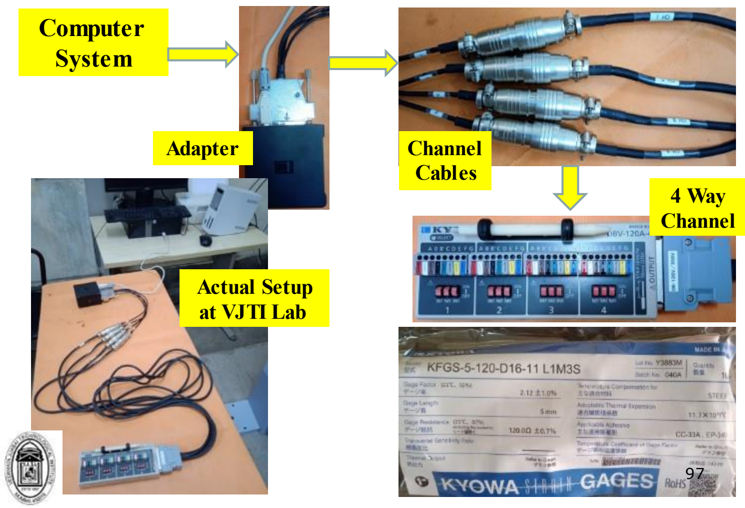
Testing setup for Poison’s Ratio (PR) at VJTI



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Testing setup for Poison’s Ratio (PR) at VJTI

Tensile specimens for PR Test

Specimen ready with Strain Gauge

PR Test DAS with Shimadzu

KYOWA Screen for PR Test

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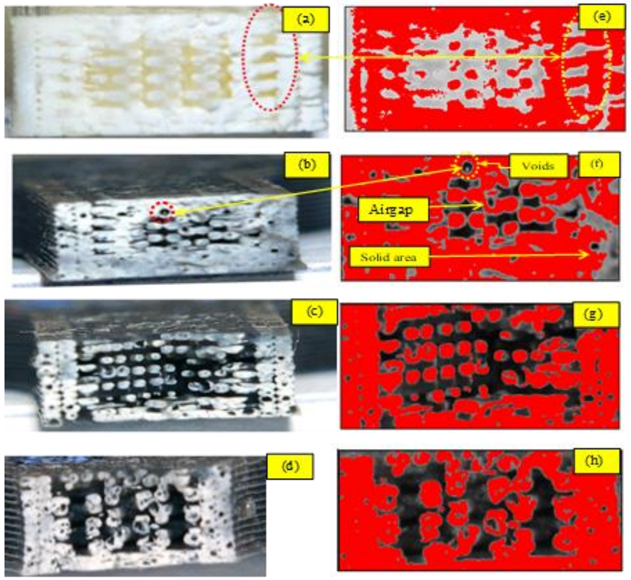

Void Fraction Analysis: 100% in-fill: Macro graphic images

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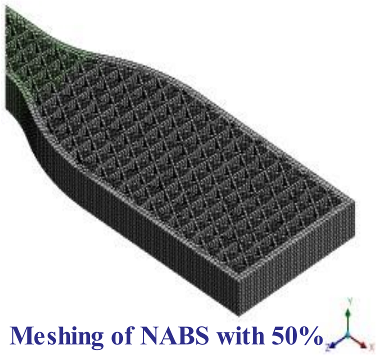
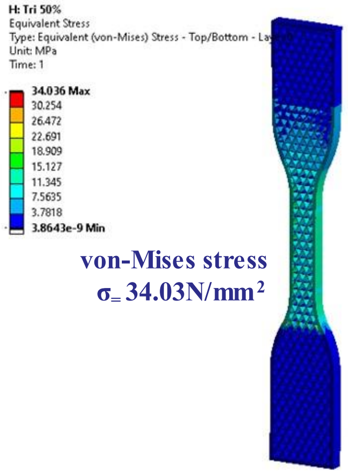
Finite Element Analysis for NABS -MWCNT nanocomposite contd….



Meshing of NABS with 50% in-fill Triangular pattern.



von-Mises stress
σ= 34.03N/mm^2

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• Molecular Dynamic Simulation and materials multicale modeling and analysis

Steps followed in MD simulation

The molecular dynamic simulations were carried out using **COGNAC in J-OCTA (JSOL Corporation Japan) package.** Periodic boundary conditions were applied in neat resin polymer model to replicate the cell in all three dimensions. Following are the steps followed during MD simulation.

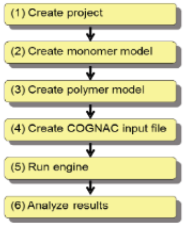

Figure 6: Steps in MD Simulation

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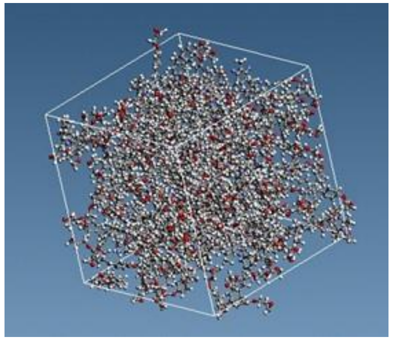
100 molecules of DGEBF and 50 molecules DETDA so that mixing ratio of 73.6:26.4

- COGNAC input file is generated by applying periodic boundary condition in all three direction and cell size taken is 40 x 40 x40 A ^{0}. Expected density is set to 1.2gm/cm ^{3}.
- NVE (constant number of molecule, constant volume and constant energy) ensemble is applied temp. is kept at 300K, time interval taken as 30 fs.
- First 2 MD simulation are carried out for achieving energy minimization.



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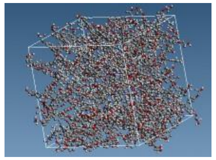
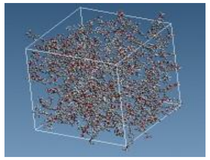
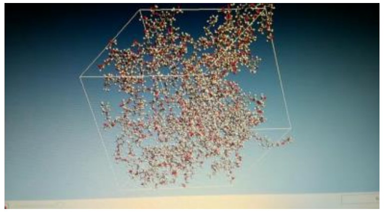
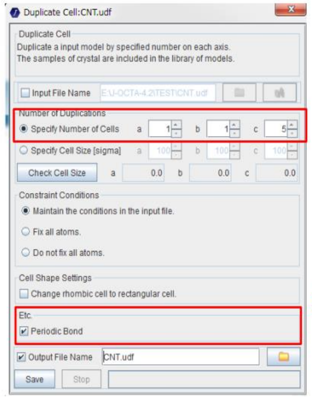
MD simulation result for 150 Molecules of DGEBF and 75 DETDA Molecules

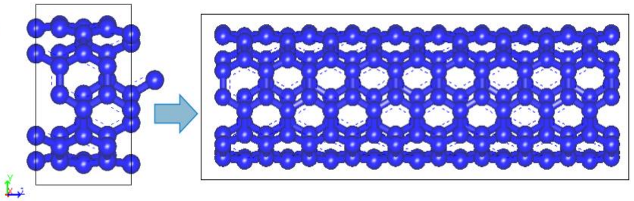






180

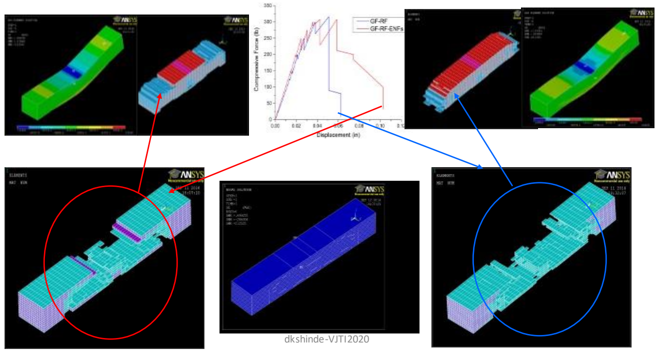




• FEM Analysis of Short Beam Strength of FRPCcomposites and Nanocomposites

Progressive failure analysis of GF -RF and ENFs composite

- Comparison of experimental and FEM results GF -RF and ENFs composites in three point bending



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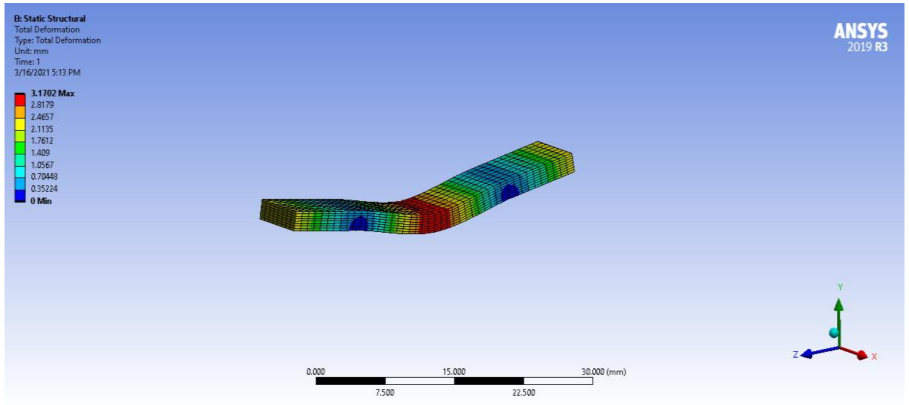
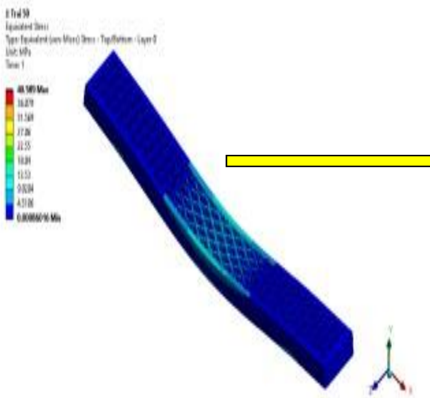


Finite Element Analysis for Flexural testing contd..



von-Mises stress
$\sigma_{=}$ 40.58 N/mm²

Stress plot for NABS with 0.1% MWCNTs for 20% infill triangular pattern

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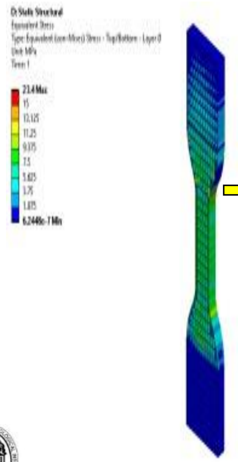
Finite Element Analysis for NABS -MWCNT nanocomposite contd…..



von-Mises stress
$\sigma_{=}$ 23.4N/mm²
NABS
with
0.2% MWCNTs
in 20% in -fill
Rectilinear
pattern.

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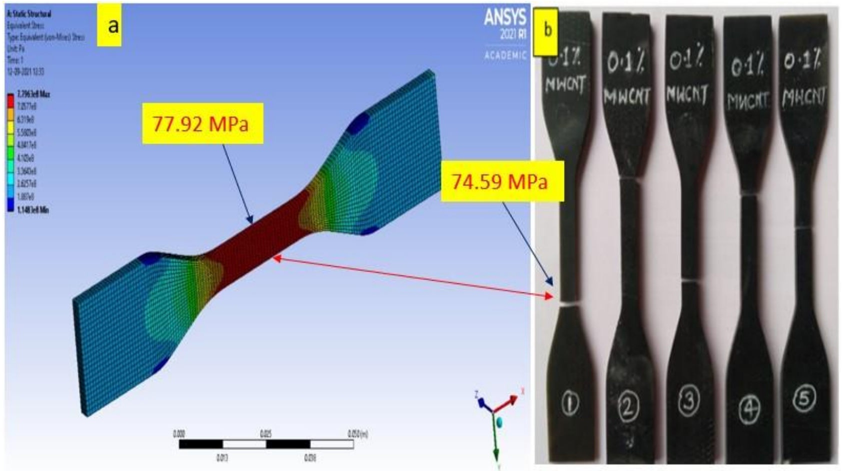
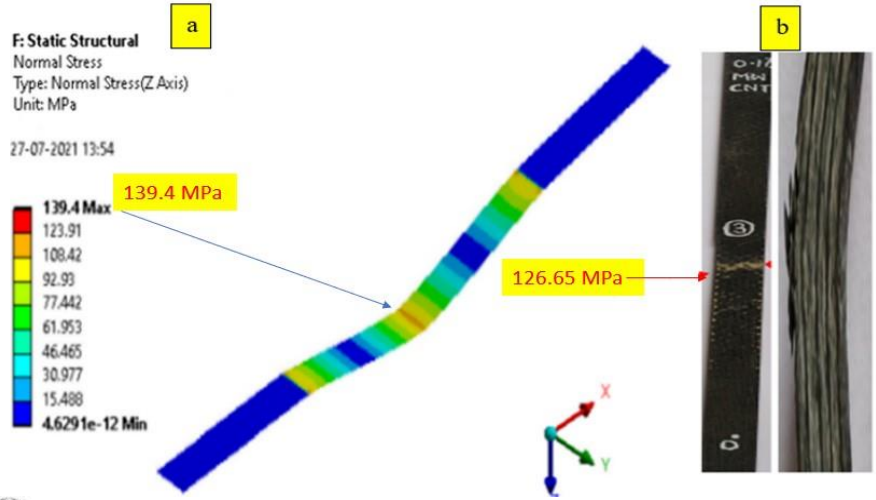
FE Analysis of Neat Epoxy and Polymeric Nanocomposite Cont…



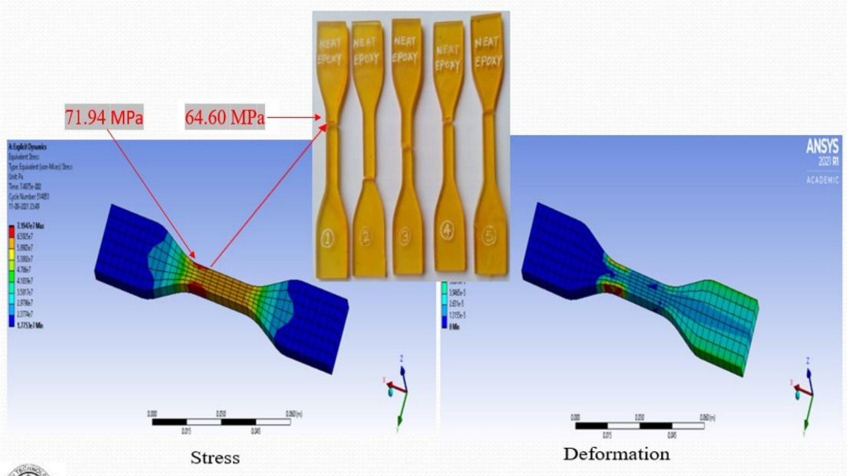
Correlation between failure region observed in the specimen of hybrid nanocomposite with 0.1% MWCNTs during (a) FEA; (b) Photograph of failed sample [129]

FE Analysis of Fiber Reinforced Hybrid Composite



Flexural strength of fiber reinforced hybrid composites for 45 ˚fiber orientations along z - axis (a) FEA failure region (b) photograph of failure region of specimen [132]

FE Analysis of Neat Epoxy and Polymeric Nanocomposite Cont…



Comparison of FEA stress distribution against actual mode obtained through experiments

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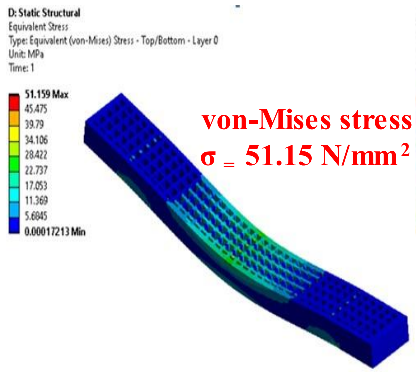
Finite Element Analysis for Flexural testing contd..



Stress plot for NABS with 0.1% MWCNTs for 50% in-fill Rectilinear pattern

Stress plot for NABS with 0.2% MWCNTs for 50% in-fill Grid pattern

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Outcome of the CAMRIM Centre from 2017 onwards

Total equipment of worth of Rs 1.30 Crores through Government of MHRD TEQIP-II and III and AICTE funding agencies.

- **5 M Tech Thesis are completed**
- **6 Ph D Dissertation are completed**
- **20 Journal and Peer Reviewed Conference Articles are published**
- **4 Patents are published**

Publications:

1. Divyanka M Sontakke, **Dattaji K Shinde**, "Development and Characterization of Electrode using PAN/TiO2 Nanofibers to improve the Battery Capacity" *Springer International Conference on Recent Evolutions in Energy, Drives and e-Vehicles -REEDeV-2022*, Nagpur, September 16-17, 2022 paper Id-34.
2. Suhas A.Uthale, **Dattaji K. Shinde**, Nadir Ayrilmis (2021), *Experimental Study for Flexural Rigidity and Cost Optimization of the Woven Fabric Glass/Carbon/Basalt and Hybrid Epoxy Composites*, Journal of Xi'an University of Architecture & Technology, Volume XIII, Issue 7, pg. 683-695.
3. Suhas A. Uthale, Nitin Dhamal, **Dattaji K. Shinde**, Ajit D Kelkar (2021), *Polymeric hybrid nanocomposites processing and finite element modeling: An overview, Science, Progress 2021, Vol.104(3) 1–44 DOI: 10.1177/00368504211029471*.
4. Divyanka Sontakke, Amit D. Kamble, **Dattaji K Shinde**, Nadir, Ayrilmis (2021), Synthesis and Characterization of PAN/TiO_2 Based Carbon Nanofibers for Energy Application, *Journal of Xi'an University of Architecture & Technology* Volume XIII, Issue 7, Page. 213-225. https://doi.org/10.37896/JXAT13.7/31321
5. Aliasgar Bohara1, **D. K. Shinde.** (2018). Synthesis and Characterization of Graphene based Acrylonitrile Butadiene Styrene Nanocomposite Using Fused Deposition Method. Processing of 4th International Conference on Nanotechnology- Applications, Advances and Innovations NANOCON 2018.
6. **Dattaji. K. Shinde**, S. C. K. (2019). A review on study of polymers and recent development and future challenges in materials for additive

manufacturing-3D printing. *Additive Manufacturing Journal*, *1*(3), 53-62.

7. Divyanka Sontakke, A. T., **D. K Shinde**, Sujata Parmeshwaran. (2019). Morphological and Electrical Characterization of Polyacrylonitrile Nanofibers Synthesized Using Electrospinning Method for Electrical Application. *International Journal of Electrical and Computer Engineering*, *13*(06), 421-426.

8. Emmanwori, L., **Shinde, D. K**., & Kelkar, A. D. (2013). Mechanical properties assessment of electrospun TEOS nanofibers with epon 862/w resin system in a fiber glass composite. 45th ISTC - Wichita KS - Oct 21-24 / 2013,

9. Gokhare, V. G., Raut, D., & **Shinde, D. K**. (2017). A review paper on 3D-Printing aspects and various processes used in the 3D-Printing. *Int. J. Eng. Res. Technol*, *6*, 953-958.

10. Kulkarni, S. C., J. S., & **Shinde D. K**. (2019). Mechanical and Electrical Properties of Carbon Nanotubes Based Acrylonitrile Butadiene Styrene Nanocomposite Fabricated Using Fused Deposition Method. SAMPE 2019,

11. MASAB USMANI, **D. K. Shinde.,** D N Raut. (2018). Design and fabrication Process of Chemical Storage tank of Fiberglass polymeric composite and its failure analysis. The Proceeding of 34th Value Engineering International Conference. -SAVE international 2018 Mumbai,

12. Nilesh B. Shahapure, A. D. K., **Dattaji. K. Shinde.** (2021). Molecular Dynamic Simulation and Experimental Investigation of Short Glass Fiber Reinforced Polymeric Nanocomposites for Mechanical Properties. SAMPE Virtual Conference Proceedings. Long Beach, CA, June 29-July 1, 2021. Society for the Advancement of Material and Process Engineering – North America.,

13. Pillewan, V., Raut, D., Patil, K., & **Shinde, D. K.** (2017). Carbon Nanotubes Based Porous Framework for Filtration Applications Using Industrial Grinding Waste. *International Journal of Materials and Metallurgical Engineering*, *11*(2), 202-208.

14. Pillewan, V., Raut, D., Patil, K., & **Shinde, D. K**. (2018). Carbon to Carbon Nanotubes Synthesis Process: An Experimental and Numerical Study. *Materials Today: Proceedings*, *5*(2), 6444-6452.

15. Sachin C. Kulkarni, **D. K. Shinde.** (2021). Effect of In Fill Patterns on 3D Printed Multi-Wall Carbon Nanotube Based Acrylonitrile Butadiene Styrene Nanocomposite on Mechanical Properties. SAMPE Virtual Conference Proceedings. Long Beach, CA, June 29-July 1, 2021. Society for the Advancement of Material and Process Engineering – North America.,

16. Sachin C. Kulkarni, J. S., **Dattaji. K. Shinde**. (2019). Mechanical and electrical properties of carbon nanotubes based acrylonitrile butadiene styrene nanocomposite fabricated using fused deposition method. SAMPE Conference Proceedings. Charlotte, NC, May 20-23, 2019. Society for the Advancement of Material and Process Engineering – North America. DOI: https://doi.org/10.33599/nasampe/s.19.1406,

17. **Shinde, D. K**., & Kelkar, A. D. (2016). Short Beam Strength of Laminated Fiberglass Composite with and Without Electospun TEOS

Nanofibers. SAMPE 2016 - Long Beach CA USA, May 23-26 / 2016,

18. Suhas Uthale, **D. K. Shinde**. (2020). Mechanical characterization of neat epoxy resin and its failure analysis using FEM. International Conference on Functional Materials-2020 (ICFM-2020), *Proceeding of the International Conference on Functional Materials-2020 (ICFM-2020) to be held during January 6-8, 2020, at Indian Institute of Technology Kharagpur West Bengal 721302.*
19. Suhas Uthale, N. D., **Dattaji. K. Shinde**. (2021). Comparison of Mechanical Properties of Hybrid Woven Fabric Reinforced Epoxy Composites Fabricated Using of Glass Carbon and Basalt Fibers. SAMPE Virtual Conference Proceedings. Long Beach, CA, June 29-July 1, 2021. Society for the Advancement of Material and Process Engineering– North America.,
20. Pillewan, V., Raut, D., Patil, K., & Shinde, D. K. (2019). Thermogravimetric/Differential Thermal Analysis (TG–DTA) of Binary Metal Catalyst for Multiwall Carbon Nanotube (MWCNT) Synthesis. *Mechanical Engineering for Sustainable Development: State-of-the-Art Research*, 105. , *PART II: MATERIALS AND MANUFACTURING (MM) 12. TG-DTA Analysis of a Binary Metal Catalyst for Multi-Wall Carbon Nanotubes Synthesis* (pp. 677). AAP CRC Press book chapters by Talyors & Francis.

List equipment

Sr. No	Instruments	Estimated cost (INR)
1	Electrospinning unit Advanced features with computer control operations	8,26,500.00
2	HAMCO101LABORATORY OVEN MEMMERT MODEL Industrial Oven Electric Or Gas Fired	1,00,000.00
3	Universal Testing Machine – Shimadzu model AGS-100kNX Floor Type capacity 100kN.	50,00,000
4	HIGH VACUUM PUMP 2 HP, 750 LPM : 0.05 TORR	42,100
5	Dynamic Mechanical Analyser, DMA 7100 from Hitachi High Tech Science Corporation, Japan	62,325
6	DSC 6000 Differential Scanning Calorimeter	31,860.00
7	Motic Research Advance Trinocular Microscope Model BA410E with Fluorescence attachment and Dedicated Scientific 5-megapixel Digital Camera Moticam 5 with image analysis software	4,20,176.00
8	Composite Manufacturing Hoods with glass plate open mould	3,00,000
9	Abrasive Water jet cutting Machine	45,00,000
10	Accessory and Miscellaneous	2,00,000
11	Sigma mixture (0.5 liters Capacity)	4,70,000
12	Injection molding machine	2,35,000
13	Micro Weighing machine (Digital)	79,000

14	Electrically Heated Circular Horizontal Tabular Furnace (Temp.- upto 1350^{o}c)	3,20,000
15	Rotameters	10,913
16	Hydrogen cylinder and Regulators	20,000
17	Nitrogen cylinder and Regulators	20,000
18	Argon cylinder and Regulators	20,000
19	Acetylene cylinder and Regulators	25,000
Total cost of equipment		**119,82,874.00**

• My Research Team

Research Scholars under supervision of Dr. Dattaji. K. Shinde

Mr. Nilesh Shahapure

Experimental and Simulation Based Study for Mechanical Characterization of Epoxy/CNT Nanocomposites

Mr.Suhas A. Uthale

Development and Finite element analysis of woven fiber hybrid polymeric nanocomposite to enhance flexure and shear properties

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Research Scholars under supervision of Dr. Dattaji. K. Shinde

Mr. Sachin Kulkarni

Mechanical and Electrical Properties of Carbon Nanotubes based Acrylonitrile Butadine Styrene Nanocomposite Fabricated using Fused Deposition Method

Mrs .Divyanka Darshan Ingale

Morphological and Electrical Characterization of Polyacrylonitrile Nanofibers Synthesized using Electrospinning Method for Electrical Application

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Research Scholars Under supervision of Dr. Dattaji. K. Shinde

Mr. Nitin Anandrao Dhamal

Effect of Nanoclay/CNT on Mechanical and Environmental properties of Fiber glass laminated Polymer Composites

Mr. Amit Kamble

Synthesize and Characterization of Glass

Acknowledgement

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- My parent institute: Author acknowledges the facilities provided by Centre for Advanced Material research and Innovative Manufacturing (CAMRIM) at Veermata Jijabai Technological Institute (VJTI), Matunga, Mumbai, for the equipments and materials through MHRD's TEQIP-II and III funding agency for this research work.