Rheological and Visco-elastic Performance Evaluation of SBC Electrospun nanofiber/Epoxy composites: Experimental Data vs models

Battula Durga Siva Deeraj*, Kuruvilla Joseph
Department of Chemistry, Indian Institute of Space Science and Technology
Trivandrum, Kerala, 695547

INTRODUCTION

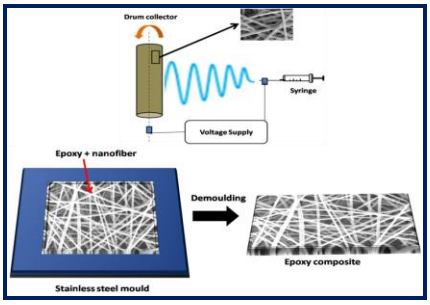
•Epoxy is mostly used thermosetting polymer with excellent mechanical performance

•Inherent brittleness of cured epoxy limits it use in advanced applications. So, secondary phases are incorporated in epoxy to make it tough.

•Incorporation of rubbery phases in epoxy decrease its mechanical performance.

•Our group is working to develop novel modifiers to improve both toughness and mechanical performance.

•We propose novel Electrospun fiber/epoxy composites as high performance composites.



Schematic Representation

•Electrospinning is a versatile method to prepare fibers in nano and sub micron scale

•Electrospun fibers offers advantages like

➢High surface area to volume ratio

➢ Wide variety of polymers and materials have been used to form nanofibers

➢Ease of fiber functionalization

➢Ease of material combination

➢Relatively low start up cost

➢Ease of fiber deposition onto other substrates

•In this work Electrospun SBC/Epoxy composites were developed and characterized.

Preparation of SBC fibers

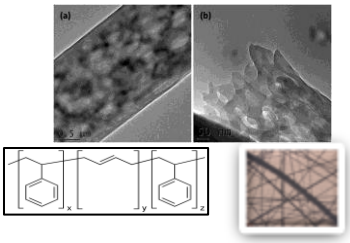
1.8 gms of SBC pellets in THF/DMF(7.5/2.5)

↓

Acc. Voltage: 10 KV
Flow rate: 20 ml/hr
Distance: 15 cms
Rotation: 1000 rpm

↓

400-900 nm



•Flexible and rubbery nanofibers

•Easy to separate out and disperse

Preparation of SBC Epoxy composites

Electrospun mat

↓

Chopped pieces

↓

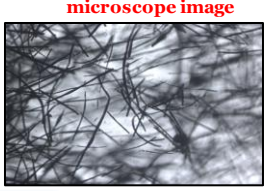
Incorporation in epoxy (0,1,2.5 & 5 w%)

↓

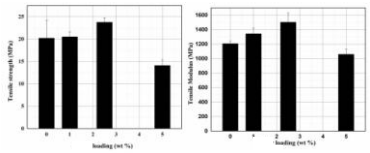
Curing in air oven 60 °C, 1 hr 80 °C, 4 hr

Epoxy: GY 250 (DGEBA)
Hardener: AR 140

Polarized light microscope image



Static mechanical properties



➢20% improvement in Tensile strength

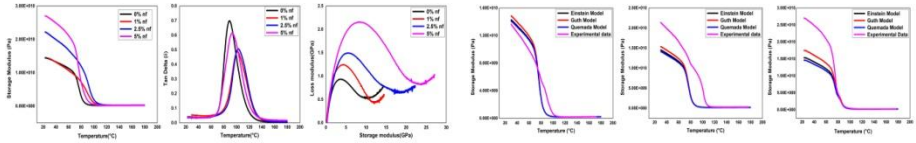
➢ 25% Improvement in Tensile modulus

Dynamic mechanical properties

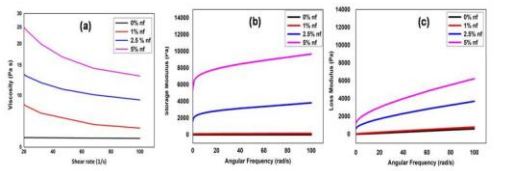
➢ More than 2 fold increase in the storage modulus

➢Positive shift in T_g

➢ visco-elastic properties are modeled with Einstein,Guth and Quemada models



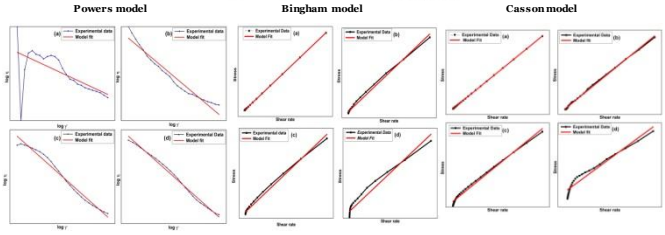
Rheological properties



➢ Near Newtonian to Shear thinning behavior

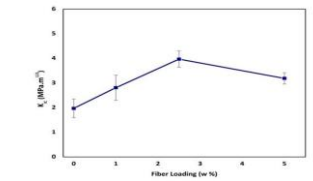
➢ Storage and loss modulus increase with fiber loading

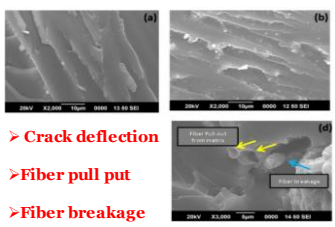
Powers model | Bingham model | Casson model



Fracture Toughness

>100% Improvement





➢ Crack deflection

➢Fiber pull put

➢Fiber breakage

Conclusion

➢Electrospun fibers of SBC were successfully made and SBC/Epoxy composites were made

➢Almost 2 folds increase in storage modulus is observed

➢The fracture toughness of these composites increased more than 100%

➢modeling of visco-elastic and rheological data was done and compared with the experimental data

➢ novel advanced composite system were developed for high performance applications

Acknowledgements

•IIST, ISRO

•STIC CUSAT Cochin