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Structural Integrity and Thermomechanical Response of Fe_3O_4/Carbon Nanotubes/Epoxy Resin Hybrid Nanocomposites

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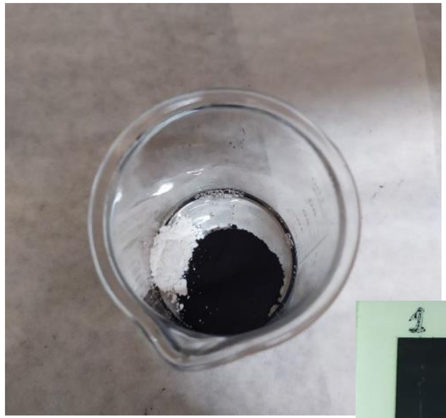
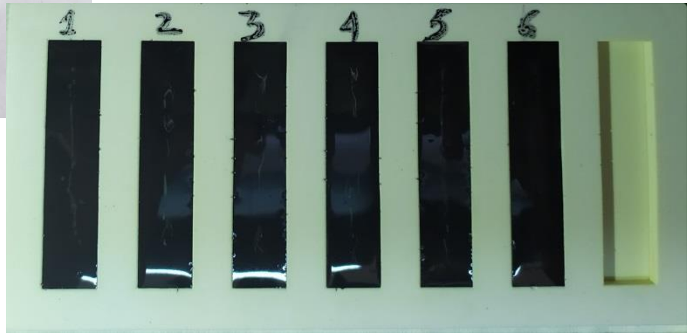
01. INTRODUCTION

In this research polymer hybrid nanocomposite systems were fabricated and studied varying the filler content. Epoxy resin was used as a polymer matrix, while multiwall carbon nanotubes (MWCNTs) and magnetite (Fe_3O_4) nanoparticles were acting as fillers. Their mechanical properties under dynamic and static conditions were tested via Dynamic Mechanical Analysis (DMA) and Tensile tests respectively.





02. EXPERIMENTAL

Low viscosity epoxy resin (Epoxol 2004 A) and curing agent (Epoxol 2004 B) provided by NEOTEX SA. were used as a matrix. Multiwall carbon nanotubes with diameter 5-20 nm and magnetite nanoparticles with diameter 50-100 nm, all provided by Sigma-Aldrich, acted as reinforcing phases. Six composite specimens were manufactured with content 5, 10, 15, 20, 40 and 50 phr (parts per hundred resin per mass) Fe_3O_4 powder, while the amount of CNTs was constant in all specimens (5 phr). For comparison reasons, an unfilled epoxy specimen was prepared.

- Mixing epoxy resin with CNTs and Fe_3O_4 nanoparticles.
- The mixture was stirred using a sonicator at T=50ºC for 10 min.
- The curing agent was added in the mixture in a 2:1 w/w mixing ratio, at ambient temperature for 10 min.
- Curing at ambient temperature for 7 days.
- Post curing at T=120ºC for 4 h.

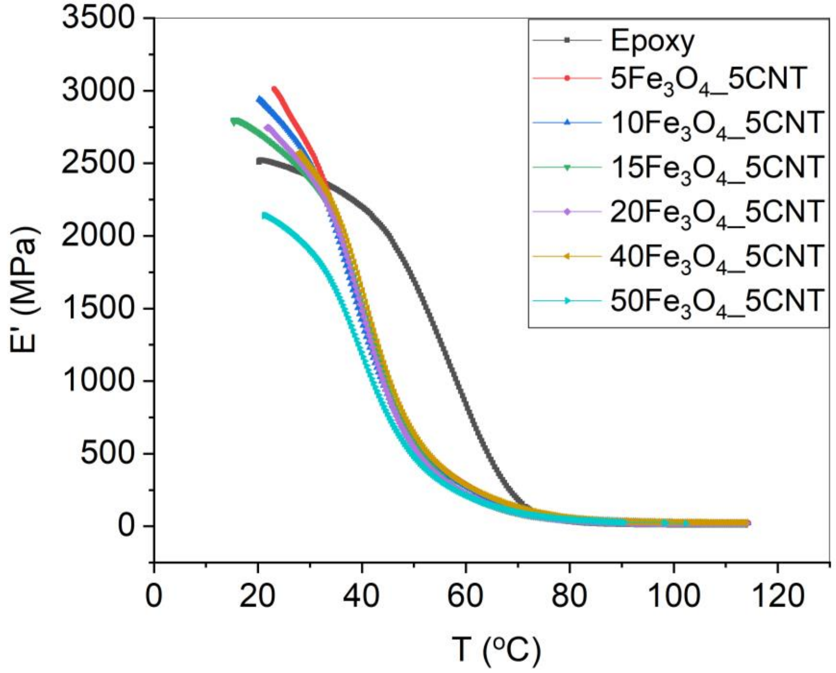
Characterization Techniques

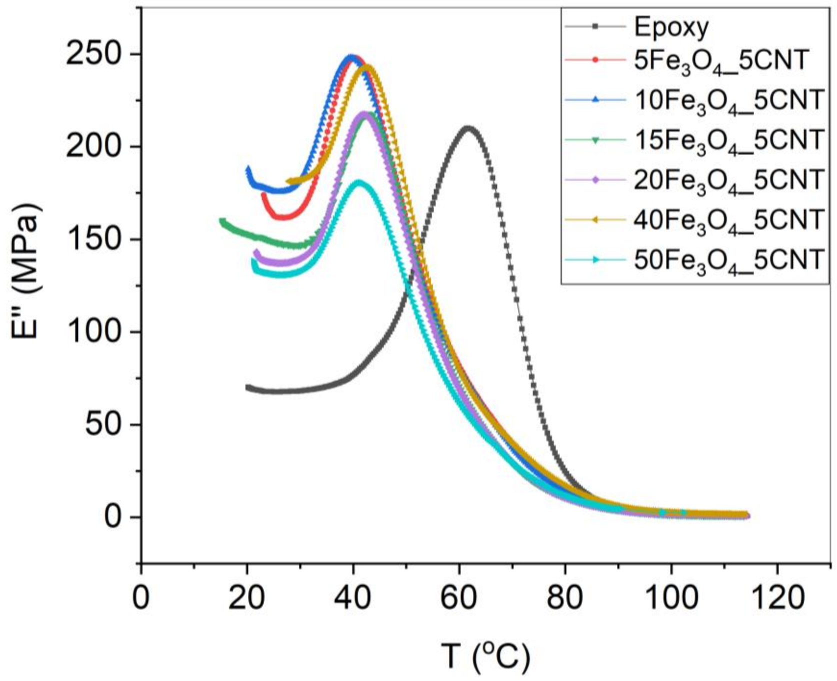
DMA: Q800 TA instruments. From room temperature to 120ºC, at a heating rate 5ºC /min, and at a constant applied frequency of 1 Hz.

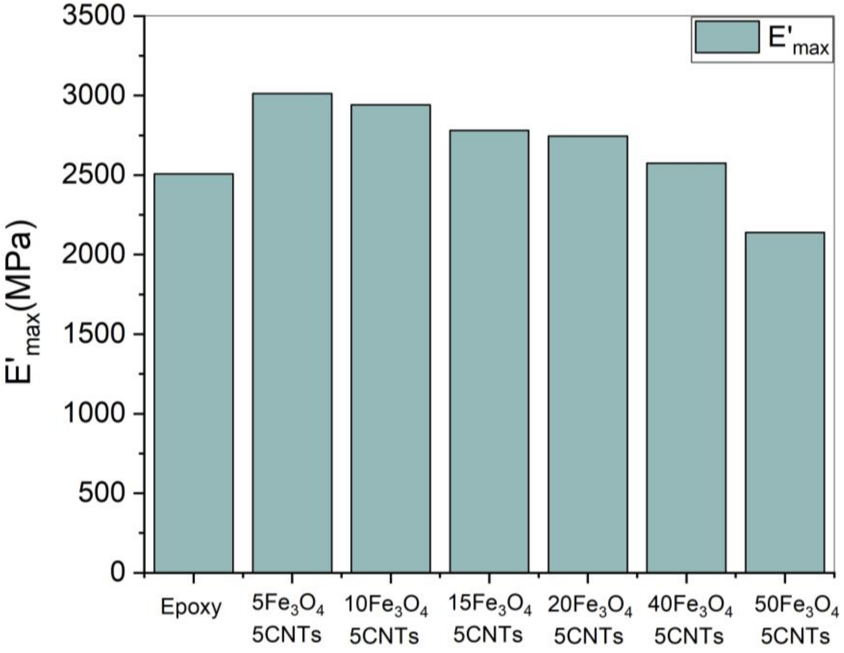
Instron: Tensile test, 8552, strain rate 5 mm/min.

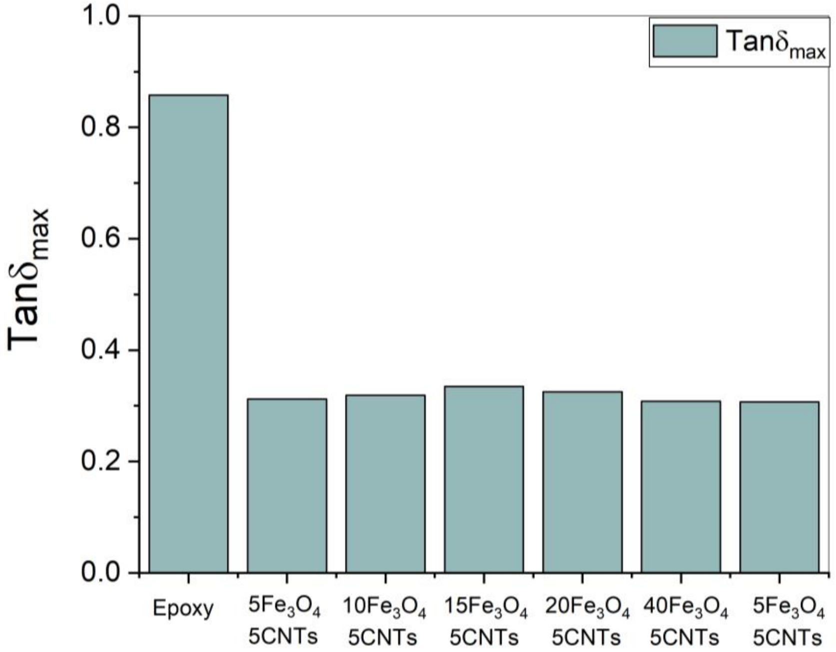
03. RESULTS

DMA RESULTS

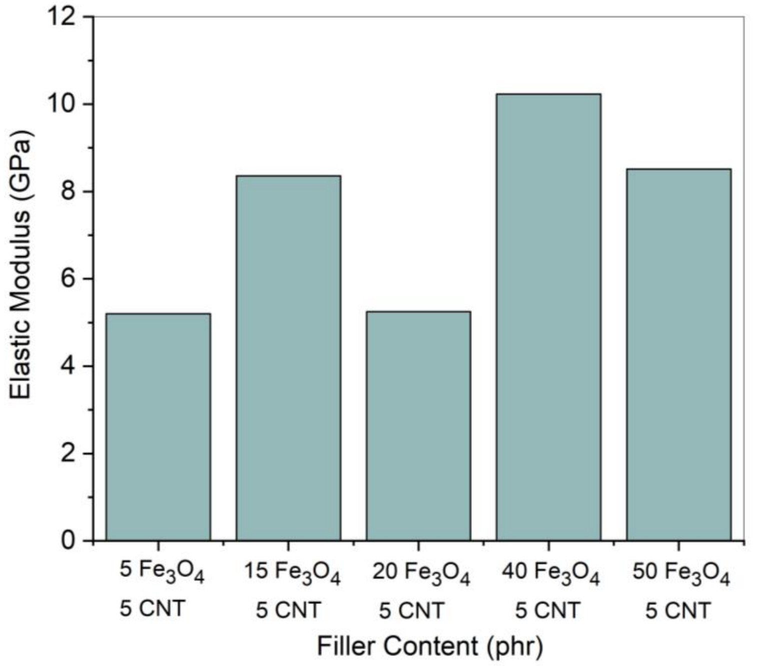


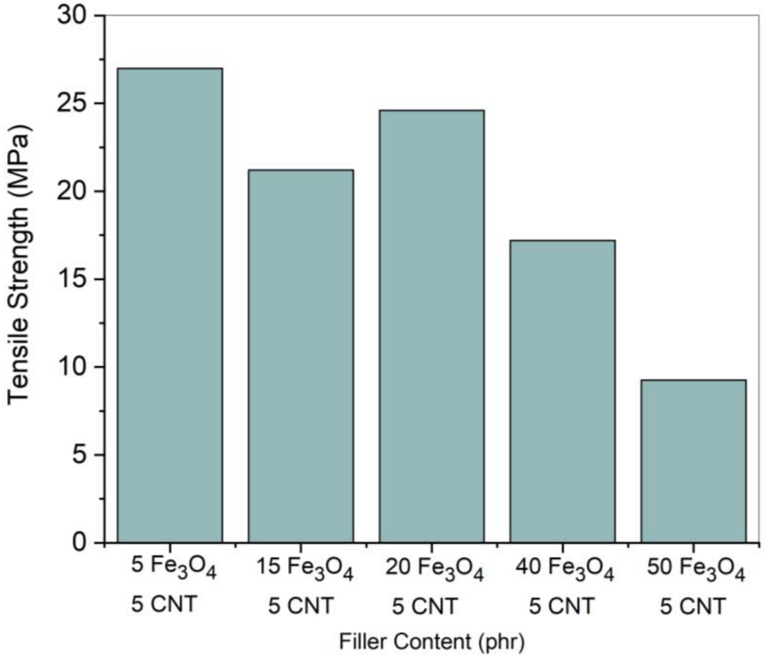


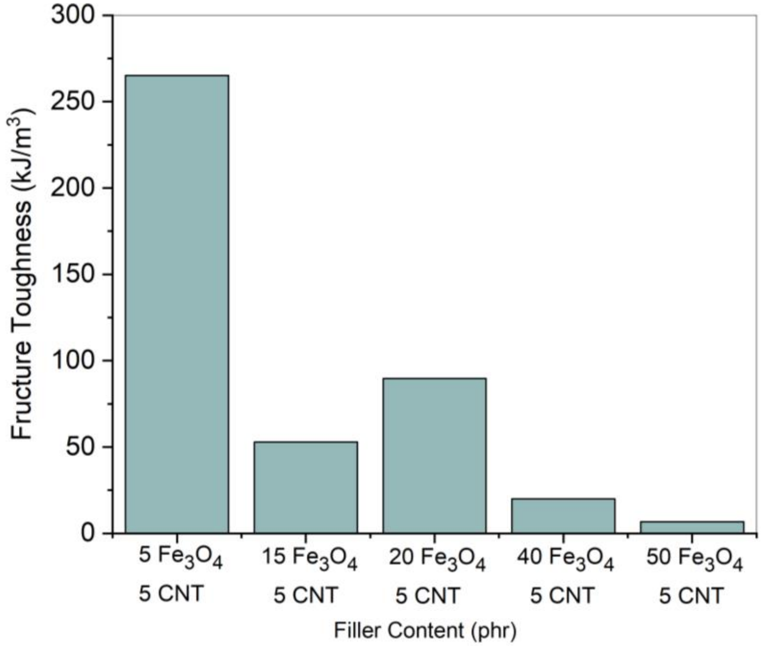




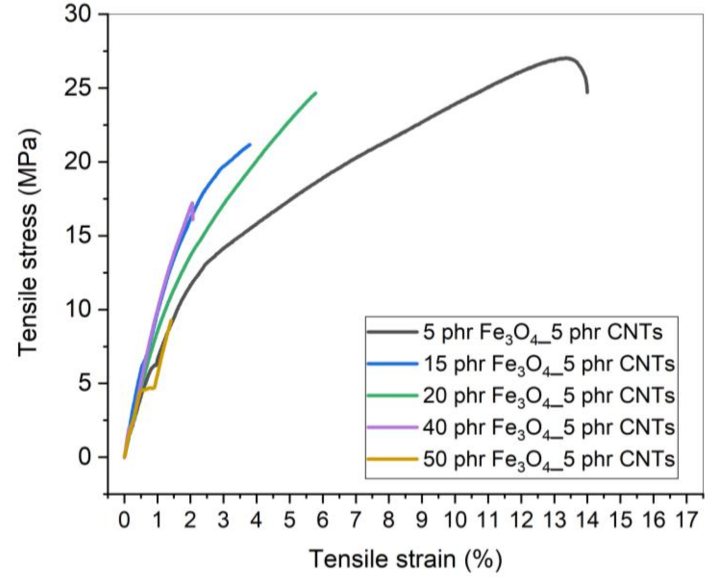
03. RESULTS







TENSILE TESTS (INSTRON) RESULTS



04. CONCLUSIONS

- Storage Modulus (E′) starts from high values, followed by a decrease in the form of a step-like transition → transition from the glassy to the rubbery state of the polymer matrix.
- In the range of the step-like transition peaks are formed in the loss modulus spectra indicating the onset of glass to rubber transition.
- The max value of E′ is observed at the 5 phr Fe_3O_4 /5 phr CNTs system. Further enhancement of the Fe_3O_4 particles content gradually reduces the storage modulus's max value of the nanocomposites.
- Glass transition temperature shifts to lower temperatures with the addition of filler compared to the neat matrix, implying weaker interactions between resin and magnetite/CNTs particles → T_g is decreasing.
- The higher value of Elastic Modulus is observed at 40 phr Fe_3O_4 /5 phr CNTs implying toughening of the nanocomposite's stiffness.
- Tensile Strength (TS)gradually diminishes with filler content. This decrement might be attributed to the low ability of stress transfer by particles, weak interfacial bonding, and interactions between nanofillers. In addition, nanoparticles might act as stress concentration points.
- The optimal performance of Fracture Toughness is exhibited by the 5 phr Fe_3O_4 /5 phr CNTs nanocomposite. Fracture Toughness decreases with filler content indicating indirectly the strengthening ability of the nanoparticles at the cost of reducing the systems' ductility.

05. REFERENCES

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06. ACKNOWLEDGMENTS

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