Carbon Nanotubes and Graphene Nanoplatelets in Epoxy Composite: Dispersion and Synergy Effect

Atikah Binti Mohamed Hanifah

Aim

- **Composites** have excellent mechanical-to-weight ratio properties but **exhibit poor electrical properties** due to the presence of dielectric polymer.
- Integration of **carbon-based nanofillers** such as carbon black (CB), carbon nanotubes (CNT) and graphene nanoplatelets (GNP) into polymer resin can **improve the electrical performance**.
- Combination of **different types of nanofillers** can result in **synergistic effect** that can further improve the electrical properties.

Aim

- The aim of the project is to **develop conductive epoxy resin composites** by integration of carbon nanotubes and graphene nanoplatelets.

Objectives

- To investigate the **electrical and rheological properties** of nano-modified epoxy composites.
- To study the **synergistic effect** of using hybrid nanofillers in epoxy composites.

Materials and Methodology

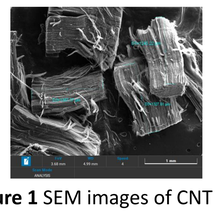

Figure 1 SEM images of CNT carpets.

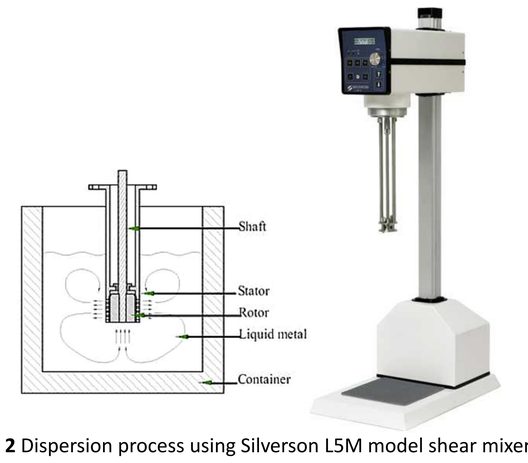

Figure 2 Dispersion process using Silverson L5M model shear mixer.

- **Highly aligned carpets of CNT** with approximate length of 1 mm was used as one of the nanofillers.
- Modified suspensions were shear mixed at **1000 RPM for 40 mins** at room temperature.

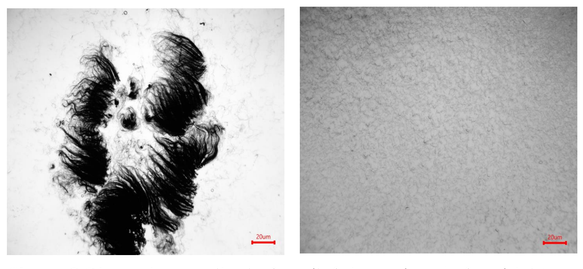

Figure 3 Dispersion quality before (left image) and after (right image) of modified suspension.

- Optical imaging shows **homogenous distribution** of nanofillers in polymer resin after mixing.
- **Through thickness electrical resistance** of cured samples was measured to investigate the bulk electrical conductivity.

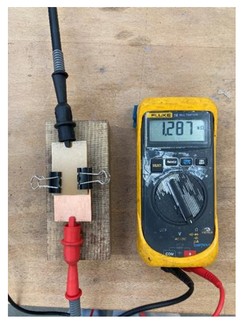

Figure 4 Electrical resistance measurement using a multimeter.

Results and Discussion

(a) CNT-modified epoxy composites

- All electrical conductivities of cured samples are within **EMI shielding range**.
- Only **slight electrical improvement** as CNT loading concentration increases.

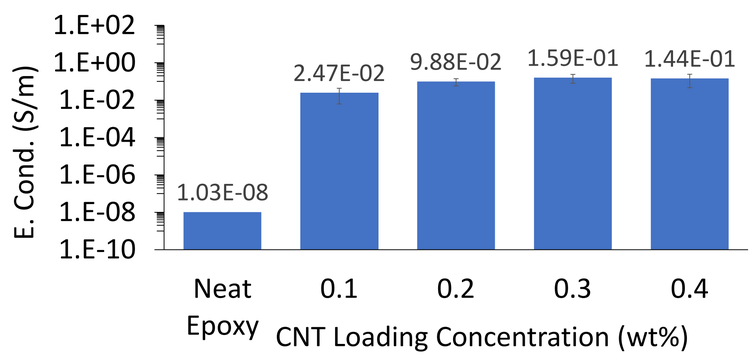

Figure 5 Electrical conductivity of CNT modified epoxy composites at different loading concentration.

- **10-fold increase** in low shear rate viscosity for 0.1wt% CNT.
- **Progressive enhancement** in low shear rate viscosity as CNT weight fraction increases.

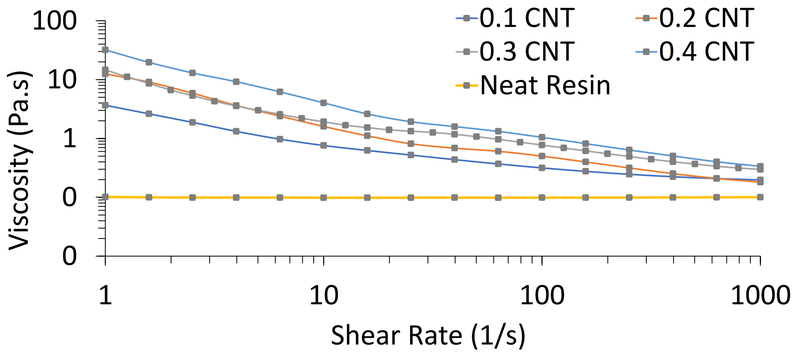

Figure 6 Viscosity of various loading concentration of CNT modified epoxy suspension at 40°.

(b) Hybrid-modified epoxy composites

- Modest **synergistic effect** – peak at **0.05 wt% GNP.**
- Maximum of **6x improvement** in electrical conductivity with addition of GNP.

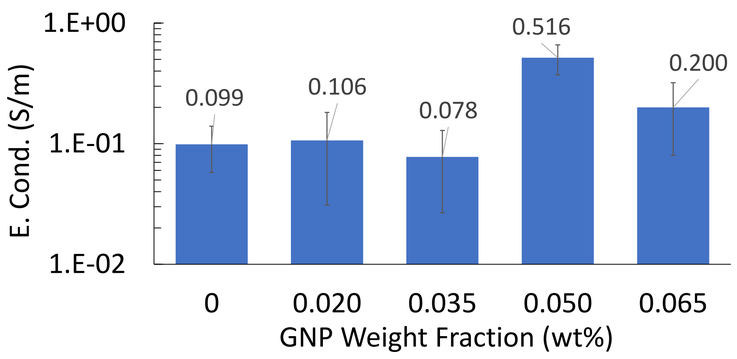

Figure 7 Electrical conductivity of hybrid modified epoxy composites at different GNP loading concentration.

- Exhibit **similar rheological behaviour** with CNT modified.

Table 1 Comparison between CNT and hybrid modified samples.

Sample	Viscosity at 1/s (Pa.s)	E. Conductivity (S/m)
0.2wt% CNT only epoxy composite	8.509	0.099
Hybrid (0.2wt% CNT + 0.05wt% GNP) epoxy composite	12.310	0.516

Conclusion

- Only **low level of CNT** weight fraction of up to 0.2wt% can be used - best **compromise between electrical conductivity and processability**.
- Slight **synergistic effect** is obtained with **addition of GNP** into CNT-only suspension.
- **Hybrid modified suspension** can further enhance the electrical performance without affecting the viscosity.

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