Mechanical and Tribological Properties of Epoxy-CNT Nanocomposite Coatings

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Introduction

The use of carbon nanotubes (CNTs, Figure 1) as filler for epoxy coatings is very promising as it is expected that the CNTs will improved the wear and impact resistance of the coatings. This, accompanied with the low friction properties of a propriety commercial epoxy make the coatings highly applicable for a number of engineering fields. The goal of this project is to perform mechanical testing on 20-100µm thick coating samples and investigate the effect of varying CNT content on these results.

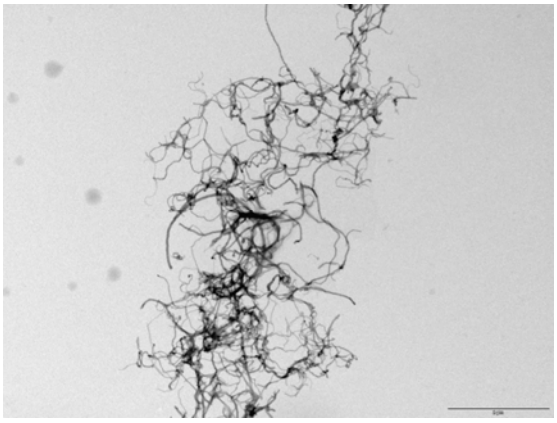

Figure 1: Multi-walled Carbon nanotubes

Coating Preparation

Previous research has shown that the dispersion of CNTs is critical to the success of epoxy-CNT composite [1-3]. An efficient dispersion process was developed using ball milling process in which the carbon nanotubes and epoxy are mixed by the impacting and shearing of steel balls in a rotating steel jar. For tribological tests, the coating was applied using an air-spray process onto mild steel substrate after cleaning with acetone. The coatings were then cured via an IR Lamp.

For hardness testing, the composite was air sprayed onto Al Foil and cured via IR Lamp. As these samples were much smaller than the tensile samples the foil was then removed by using 5% NaOH leaving the composite layer alone.

Nanostructure of Composites

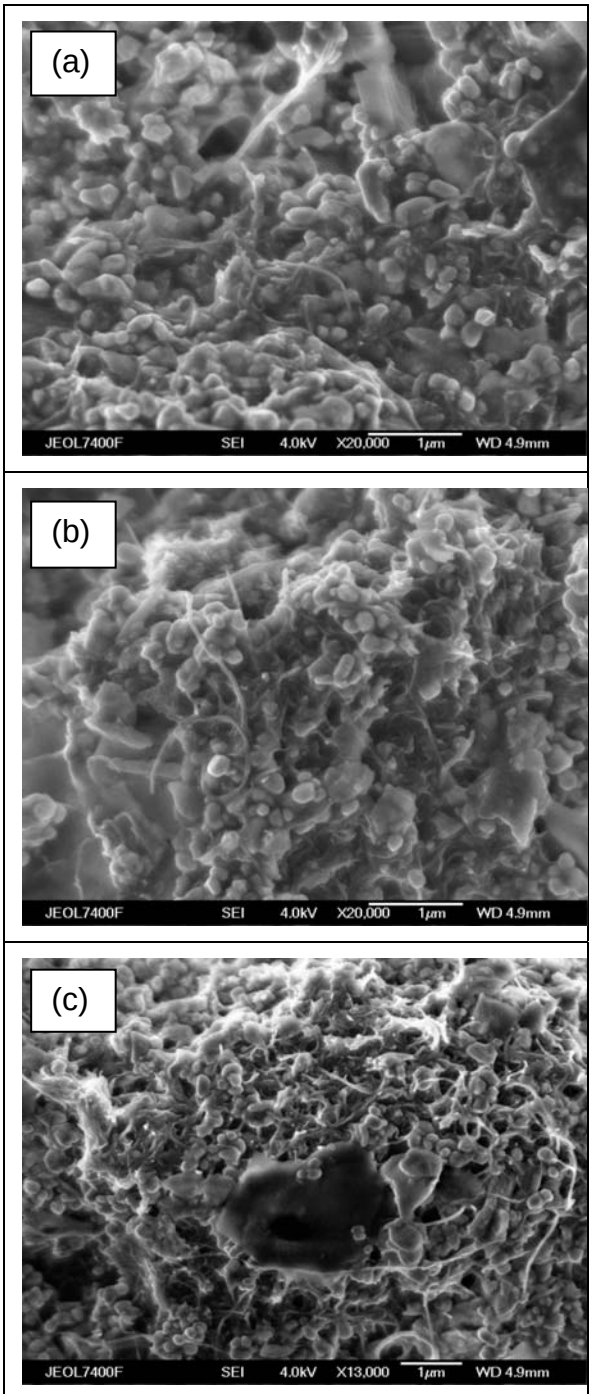

Figure 2 Nanostructure

Sprayed samples were observed under Scanning Electron Microscopy to investigate the dispersion of CNT condition as shown in Figure 2 for CNT content (a) 2wt%, (b) 2.5wt% and (c) 3.5 wt%.

The images confirm that CNTs are well dispersed at 2 wt%, but entangled bundles are found in composites with more CNTs. Large pores are found in composite with 3.5 wt% inside a cluster of CNTs. This explains the low strength of composites with high CNTs.

Mechanical Testing

Microhardness testing were carried out to determine the Vicker's hardness of the Epoxy-CNT Nanocomposite and determine the effect of CNT content on the results.

The effect of CNTs on the hardness is shown in Figure 3. The optimum Vicker's hardness occurs at 1.5-2 wt% of CNTs. The hardness is increased by 50% compared to propriety epoxy.

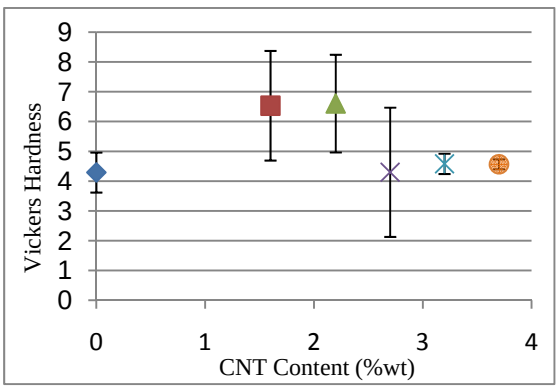

Figure 3 Effect of CNT content on the Vicker's hardness of composites

A tribological test rig was built, as shown in Fig. 4, an aluminium baseplate which supported two flexure-spring platforms. One of the platforms was constrained horizontally by a linear actuator to generate a velocity of 12 mm/min. The normal load was applied by lowering the pin in the cantilever until desirable load was achieved. The results are shown in Figure 5. The commercial epoxy coating showed a gradual increase in COF after a few cycles towards 0.3. The noise present in the friction data is owing to stronger stick-slip effect under constant high contact pressure. The composite showed a slight decrease in COF from 0.25 to 0.2 during the first few cycles before the COF stabilized at 0.2.

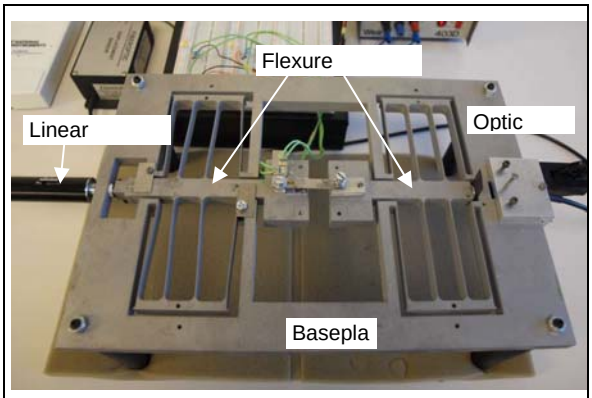

Figure 4 Friction test rig

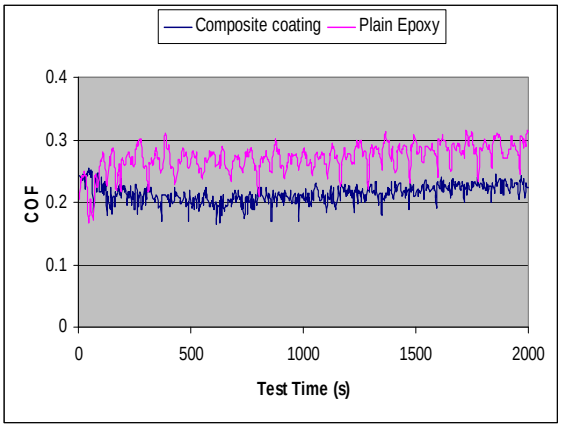

Figure 5 COF in tests under constant normal load with dia. 3mm ball on air-sprayed epoxy or epoxy-CNT composites, 16 cycles.

Conclusions

A new dispersion process was developed for epoxy-CNT nanocomposite coating. A relatively large percentage of CNTs can be dispersed in epoxy matrix. The addition of 1-2wt% CNTs improves the hardness by 50% and reduces the coefficient of friction of the commercial epoxy coating.

References

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