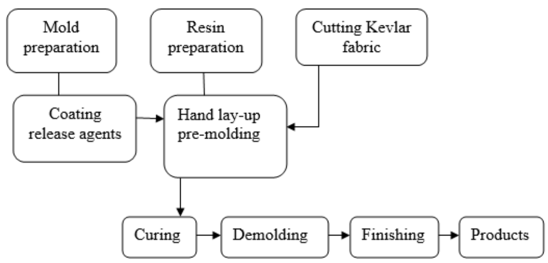
Welcome , and thank you for taking the time to view my portfolio. The goal of this portfolio is to give you a deeper insight into my experiences and skills i have gained over my recent history

Research Summary: Effects of Nano-Particles on Composite Properties

This study explores the impact of nano-particles on composites, enhancing properties such as mechanical strength, toughness, and electrical conductivity. Using Kevlar fibre, Araldite LY 556 resin, and Aradur HY 951 hardener, four specimens with varying graphene nano-filler percentages (0%, 1%, 3%, and 5%) were created. The project evaluates property changes in composites as nano-filler content increases, with the unfilled laminate as the baseline.

FABRICATION OF LAMINATES



Technique flow chart of FRP by hand lay-up

Impact Strength Test:

Impact strength is a crucial mechanical property for engineering materials. Both Izod and Charpy methods are employed to conduct impact tests on areca fiber-reinforced epoxy composites, following ASTM-D256-90 standards.

Izod Impact Test:
The Izod impact test measures a material's resistance to impact from a swinging pendulum. It quantifies the kinetic energy required to initiate and continue fracture until the specimen breaks. Notched Izod impact tests involve notching specimens to prevent deformation upon impact. This test serves as a quick quality check and allows material comparisons for toughness.

Testing Procedure:

- Use a standard specimen of 54 x 12.7 x 4-5 mm (ASTM) or a Type 1A multipurpose specimen with end tabs cut off (ISO).
- Clamp the specimen with the notched side facing the pendulum's striking edge.
- Release the pendulum to strike through the specimen, using a heavier hammer if no breakage occurs.
- In some cases, testing at reduced temperatures may simulate the intended use environment, as some materials exhibit lower impact strength at lower temperatures.

Izod impact test machine

Impact test results

In summary, our findings indicate that the impact strength exhibited an upward trend with the addition of nano-filler up to a 3% volume fraction of graphene. However, beyond this point, a detrimental effect on impact strength was observed.

Impact test specimen

Impact test (Kevlar + graphene)								
	0% graphene		1% graphene		3% graphene		5% graphene	
	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2	Specimen 1	Specimen 2
Thickness (mm)	1.29	1.32	1.4	1.63	1.69	1.55	1.89	1.95
Width (mm)	12.62	13.00	14.82	14.66	15.61	14.3	14.38	13.21
Energy absorbed (J)	0.909	1.242	1.792	1.556	2.428	2.576	1.558	1.788
Impact strength (KJ/m2)	69.62	89.61	103.89	78.50	109.58	140.84	69.28	85.61

Impact test results

Electrical Conductivity:

Electrical resistivity, denoted by the symbol "ρ," quantifies a material's resistance to electrical flow, with units in ohm·metres (Ω m). Low resistivity indicates easy electrical flow, while high resistivity signifies difficulty in conducting electricity. Copper and aluminium, with very low resistivities (around 20 nΩ m), are commonly used in electrical wires for efficient power transmission. In contrast, high-resistivity materials like certain plastics (with resistivities as high as 1 EΩ m or 1 × 10^18 Ω m) impede electric power flow.

Test Procedure:

A constant current source directs a current (I) through the sample bar, while a separate ammeter measures I. Simultaneously, a voltmeter measures the voltage (V) generated across the inner part of the bar. Alternatively, a voltage source can be used to apply voltage across outer contacts, with an ammeter in series measuring current through the sample bar.

Electric conductivity test

Results:

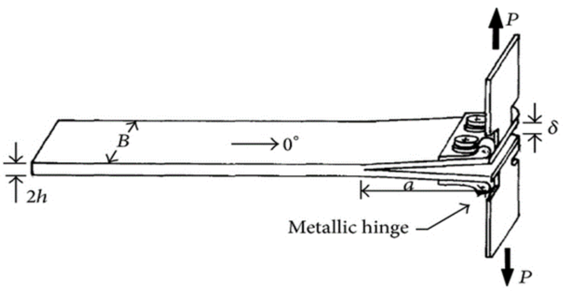
The addition of graphene to the composite resulted in an enhancement of electrical conductivity. However, while there was improvement in comparison to graphene-free laminates, the degree of improvement remained relatively minor as the percentage of graphene was varied.

ELECTRIC CONDUCTIVITY RESULTS:

PROPERTIES	1% GRAPHENE	3% GRAPHENE	5% GRAPHENE
LENGTH (mm)	10	10	10
WIDTH (mm)	25	25	25
HEIGTH (mm)	1.3	1.3	1.3
VOLTAGE (mV)	5	17	30
CURRENT (mA)	0.05	0.05	0.05
ELECTRIC RESISTIVITY(Ωm)	198.0803	198.0077	197.9218
ELECTRIC CONDUCTIVITY (S/m)	5.0484×10^{-3}	5.0503×10^{-3}	5.0525×10^{-3}

Fracture Toughness Test:

Fracture toughness quantifies a material's resistance to rapid and unlimited crack propagation at a critical stress intensity factor. It measures a material's ability to resist crack growth, and standardised values are typically available for reference.



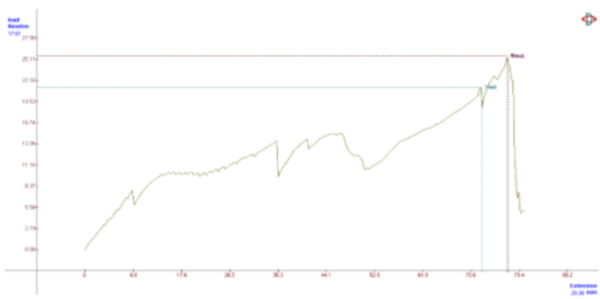
Fracture toughness test specimen

Testing Procedure:

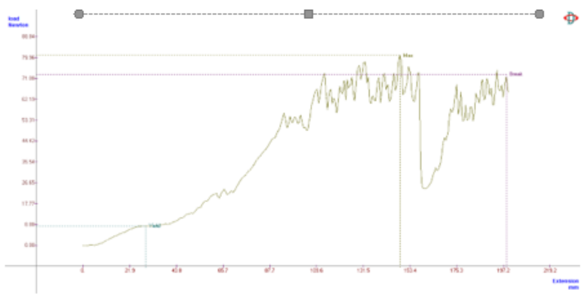
In accordance with ASTM standards, Mode I fracture toughness testing is conducted using ASTM D5528. This test assesses the opening interlaminar fracture toughness of continuous fiber-reinforced composite materials. It employs a double cantilever beam (DCB) specimen with a nonadhesive film at the midplane to initiate delamination. The test evaluates a material's susceptibility to delamination and helps establish design parameters for composite structures, considering factors such as strain energy release rate and load application (opening or tensile load per Mode I).

Results:

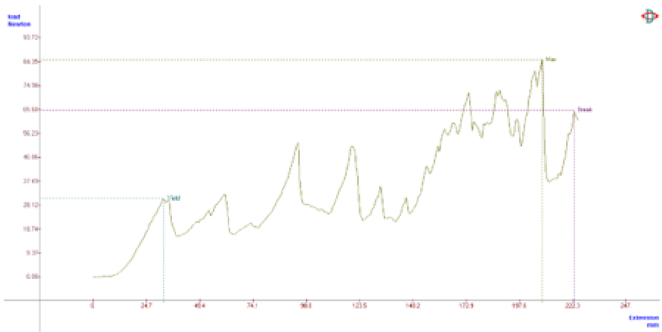
We found that fracture toughness increased with the addition of nano-filler up to a 1% volume fraction of graphene. However, beyond this point, a decrease in fracture toughness was observed.



Load vs deflection of 0% graphene specimen 1



Load vs deflection of 1% graphene specimen 1



Load vs deflection of 3% graphene specimen 1

Conclusion:

This project has revealed important insights into the performance of Kevlar-reinforced composites with the addition of graphene nano-fillers. Specifically, we observed that the impact strengt h of these composites increased as we introduced graphene nano-fillers up to a 3% weight ratio. However, beyond this threshold, the impact strength experienced a decline, likely attributed to the formation of agglomerations resulting from the high specific volume of graphene.

Additionally, the incorporation of graphene led to an improvement in electrical conductivity within the laminates. Nevertheless, further increasing the percentage of graphene did not yield significant improvements.

In terms of fracture toughness, our findings showed an increase when nano-fillers were added up to a 1% volume fraction of graphene. Subsequently, a decline in fracture toughness was observed after reaching this 1% threshold.

Considering these observations, it can be concluded that an optimal balance is achieved at a 3% volume fraction of graphene for these composite materials.