**Strength and Environmental Durability of Epoxy/Graphene Oxide Composites: An AI-Driven Framework for UAV Applications**

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## Motivation

Unmanned Aerial Vehicles (UAVs) are increasingly used for defense, surveillance, disaster management, and commercial applications. Their performance critically depends on the structural integrity and durability of lightweight composite materials. Epoxy/Graphene Oxide (E/GO) composites are promising due to their high strength-to-weight ratio and tunable mechanical properties. However, existing research largely emphasizes static mechanical performance, with limited attention to long-term environmental durability under UV, moisture, and thermal cycling. Given the operational variability of UAV environments, it is essential to assess both the strength and durability of such composites. Recent advances in Artificial Intelligence (AI), particularly Neural Networks, provide a powerful framework for predictive modeling of composite behavior under multi-factorial loading and environmental conditions.

## Objective

The study aims to develop a strength assessment and environmental durability prediction framework for E/GO composites used in UAV structures. Specifically, it intends to:

1. Evaluate the static and dynamic strength of E/GO composites.
2. Investigate the effects of accelerated aging conditions (UV, humidity, thermal cycling) on mechanical properties.
3. Extend AI-based prediction models to incorporate environmental durability parameters for long-term performance assessment.

## Methodology

The research involves a hybrid experimental–computational approach:

- Material Preparation & Testing**:** Epoxy/Graphene Oxide composites are fabricated and tested for tensile, flexural, and impact properties following ASTM standards.
- Accelerated Aging**:** Samples are subjected to accelerated aging protocol (e.g., ASTM) to simulate UV exposure, moisture ingress, and thermal cycles.
- Data Acquisition**:** Retention of strength properties is measured over aging intervals.
- AI-Extended Framework**:** A Neural Network model is trained with experimental data, with input features including GO concentration, environmental exposure parameters (time, humidity, temperature), and mechanical loading conditions. The model is designed to predict degradation trends and residual strength under coupled aging effects.

## Results

Preliminary results show that incorporation of GO enhances the initial tensile and flexural strength compared to neat epoxy. Aging experiments reveal a progressive decline in mechanical properties, with moisture absorption and UV degradation as dominant factors. The Neural Network model successfully captures nonlinear degradation trends, demonstrating predictive accuracy within ±5% of experimental results. The AI-extended framework highlights the feasibility of long-term durability prediction, which traditional empirical methods cannot efficiently address.

## Conclusion

This study provides a dual contribution: (i) establishing the superior strength potential of E/GO composites for UAV applications, and (ii) introducing an AI-extended environmental durability framework that enables predictive modeling of composite performance under aging effects. The approach not only advances the reliability of UAV structures but also opens new directions for AI-driven material design and lifecycle assessment in aerospace engineering.