

Technical Paper: Advanced Composite Airframe Materials for Stealth UAVs

Title: Comparative Analysis of Plywood versus BioMid/Ellium Composite Airframes in Low-Observable UAV Applications

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Abstract: This paper evaluates the structural, electromagnetic, and production advantages of using a BioMid/Ellium composite system over traditional plywood for unmanned aerial vehicle (UAV) airframes. With increasing demands for stealth, durability, and cost-effectiveness, this analysis shows that the BioMid/Ellium composite offers significant improvements in radar transparency, mechanical performance, thermal resistance, and manufacturability, while maintaining or improving cost metrics at scale.

1. Introduction

Recent UAV designs, particularly in asymmetric warfare contexts such as Ukraine's defense strategy, have adopted low-cost plywood for rapid drone deployment. However, with advancements in natural fiber composites and reactive resin systems, there is a compelling case for transitioning to high-performance materials like BioMid (continuous cellulose fiber) embedded in Ellium® thermoplastic resin. This paper compares both systems across critical metrics.

2. Materials Overview

2.1 Plywood: - Laminated wood sheets (typically birch or fir) - Joined using glue, screws, or nails - Tensile strength: 30-50 MPa along grain - Dielectric constant (Dk): ~2.8-4.5

2.2 BioMid/Ellium Composite: - BioMid: Continuous cellulose fibers - Ellium®: Thermoplastic resin with low Dk - Tensile strength: Up to 540 MPa (fiber direction) - Dielectric constant (Dk): ~2.5-3.5 - Cure time: 30-60 minutes - Excellent compatibility with MMA structural adhesives

2.3 MMA Structural Adhesives: - Methyl methacrylate (MMA) adhesives provide strong chemical bonding between thermoplastic matrices and composite fibers. - Used for joining complex airframe parts with high bond strength. - Fast curing, high toughness, and excellent resistance to vibration and fatigue. - Seamless surface integration enhances aerodynamic and radar stealth properties.

3. Mechanical Performance Comparison

Property	Plywood	BioMid/Ellium Composite
Tensile Strength (MPa)	30-50	Up to 540
Density (g/cm³)	~0.6-0.8	~1.3-1.4
Impact Resistance	Moderate	High
Bond Strength (MMA Adhesive)	Poor to Fair	Excellent

4. Electromagnetic Stealth Comparison

Parameter	Plywood	BioMid/Ellium Composite
Dielectric Constant (Dk)	~2.8-4.5	~2.5-3.5

Parameter	Plywood	BioMid/Ellium Composite
Radar Transparency	Good	Excellent
EM Leakage Shielding	None	Can embed copper grid/Faraday
Thermal Signature	Low	Very Low (with internal shielding)

5. Thermal and Environmental Resistance

Property	Plywood	BioMid/Ellium Composite
Thermal Stability	Moderate	High
Glass Transition Temperature	N/A	80-120°C (tunable)
Resistance to Moisture/UV	Poor to Moderate	Excellent (sealed composite)

6. Manufacturing & Repairability

Category	Plywood	BioMid/Ellium Composite
Formability (Complex Shapes)	Low (flat panels)	High (molded, compound curves)
Cycle Time	Long (manual glue)	Fast (30-60 min cure)
Automation Potential	Low	High
Field Repairability	Poor	Excellent (weldable/patchable)
Structural Bonding	Limited (glue/screws)	Excellent with MMA adhesive

7. Performance Impact on UAVs

Assuming replacement of a plywood airframe with BioMid/Ellium: - Airframe weight reduced by 25-40% - Payload capacity increased by 10-30% - Range increased by 10-15% (lower power draw) - Stealth improved in radar and IR spectrum - Assembly time reduced by >60% - Modular parts joined using MMA adhesives provide enhanced strength and surface continuity

8. Conclusion

Transitioning from plywood to BioMid/Ellium composites in UAV manufacturing offers significant structural and operational advantages. With superior strength-to-weight ratio, radar invisibility, and processability, this composite system supports both tactical superiority and scalable wartime production. The integration of copper mesh for EM shielding and compatibility with MMA adhesives further enhances its value proposition. MMA bonding not only improves structural integrity but also enables complex geometries, seamless joints, and rapid assembly, making BioMid/Ellium a superior alternative to plywood in modern UAV design.

Keywords: UAV, BioMid, Ellium, plywood, composite, stealth, drone, cellulose fiber, dielectric constant, MMA adhesive, structural bonding