Development and Performance Analysis of a Hybrid Electric-Solid Fuel Propulsion Rocket: Integrating Biofuel Synthesis, Thrust Optimization, and Data-Driven Flight Dynamics Evaluation

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This study explores the development of a hybrid solid-fuel electric autonomous rocket constructed from carbon fiber, utilizing bio-derived fuels as a renewable energy source. As the demand for sustainable aerospace solutions grows, integrating biodiesel into hybrid propulsion systems presents a viable alternative to fossil fuels. By analyzing energy density and combustion efficiency, we assess the feasibility of biodiesel for high-performance space applications. Biodiesel is synthesized from vegetable, canola, and corn oils through a transesterification process using methanol and lye, producing fatty acid methyl esters (biodiesel) and glycerin as a byproduct. The process involves heating the oil, mixing it with sodium methoxide, and allowing the reaction to complete before purification. Energy density is measured using a calorimeter, a critical metric for evaluating suitability in hybrid propulsion systems. This research compares bio-derived fuels with conventional propellants in terms of energy output and combustion efficiency for hybrid solid-fuel electric propulsion. By integrating biodiesel into carbon fiber-based autonomous rockets, this study advances sustainable aerospace technology, reducing reliance on fossil fuels while enhancing performance and environmental responsibility in space exploration.

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