

# Thermal Stability and Impact Performance of Basalt–Carbon Hybrid Laminates in Polyimide–Phenolic Matrices

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## By

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## Abstract

The impact resistance and thermal stability of the advanced polymer composites are properties that are necessary for the components that are subjected to dynamic conditions, which show the overall reliability and service performance of the laminates applied in automotive structures, protective casings, etc. These properties prevent premature softening or breakdown during long-term exposure to heat. Impact resistance and thermal stability of composite laminates are studied based on fiber orientation and composition. Basalt and carbon fibers were reinforced in a new polyimide/phenolic resin framework processed in methane and propane derivatives of hybrid composites. Composite laminates were manufactured through compression molding, and their behavior under low-velocity impact loading was assessed at two distinct velocities – 2.89 m/s and 4.42 m/s – to determine the most effective fiber arrangement and hybrid configuration for achieving greater damage tolerance. Techniques such as thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC), and Fourier transform infrared spectroscopy (FTIR) were employed to evaluate thermal degradation patterns, phase transitions, and chemical structure stability. The combined influence of the tailored resin chemistry and basalt–carbon hybrid reinforcement significantly enhanced both impact strength and thermal resistance. The increase in material toughness and energy absorption shows an increase in the glass transition temperature and initial decomposition temperature at 5% mass loss.