

**EVALUATION OF CRITICAL FIBRE LENGTHS FOR SURFACE-TREATED  
PINEAPPLE LEAF FIBRES INCORPORATED  
NATURAL RUBBER COMPOSITES**

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The efficacy of short natural fibre-reinforced composites is critically influenced by the critical fibre length, a parameter essential for optimal load transfer and reinforcement within the polymer matrix. This study investigated the critical fibre lengths of untreated and various surface-treated pineapple leaf fibres (PALF) embedded in a natural rubber matrix. For better adhesion between natural fibres and the rubber matrix, surface treatments were employed, including NaOH treatment and NaOH pre-treatment followed by salicylic acid, silane coupling agent (Si 69), and poly(ethylene glycol) (PEG) treatments. Untreated PALF served as the control. Fourier transform infrared spectroscopy was used to characterize the chemical modifications induced by these treated PALF fibres. The critical fibre lengths were determined through the single fibre pullout test, tensile strength measurements of individual fibres, and fibre diameter assessments. The findings revealed critical fibre lengths of 5.96 mm (untreated PALF), 4.48 mm (NaOH-treated PALF), 4.76 mm (salicylic acid-treated PALF), 5.07 mm (PEG-treated PALF), and 2.44 mm (Si 69 treated PALF). These results indicate that surface treatments significantly enhance the fibre-matrix adhesion, thereby reducing the critical fibre length required for effective reinforcement of natural rubber composites. Among the treatments, Si 69 demonstrated the most pronounced improvement in fiber-matrix compatibility. This research underscores the pivotal role of fibre surface treatment in optimizing the mechanical performance of natural fibre-reinforced natural rubber composites, providing valuable insights for future material development.

**Keywords:** Critical fibre length, Natural rubber, Pineapple leaf fibre (PALF), Surface treatment