Dragonfly-Inspired Flapping Wing Fabrication Using PVDF/CNT Nanocomposite Membranes and 3D-Printed Vein Structures

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Nature has long served as a blueprint for solving complex engineering challenges. Dragonfly is one of the most aerodynamically efficient flyers. Their corrugated wing membranes, hierarchical venation, and ability to exploit unsteady aerodynamic mechanisms inspire the design of next-generation flapping wing micro air vehicles (FWMAVs). In this work, a PVDF/CNT nanocomposite membrane was fabricated by solution casting with varying CNT loading, and a vein structure was generated via VAT additive manufacturing. An integration of a nanocomposite membrane with a vein structure was performed to develop a dragonfly-inspired wing. The developed wing's mechanical and structural dynamic properties were characterized using various techniques, including tensile tests, Dynamic Mechanical Analysis (DMA), vibration tests, and Digital Image Correlation (DIC). An optimal CNT loading of 1.5% was found, yielding the most suitable properties as determined by characterization techniques. Furthermore, the effect of vein integration on deformation modes and their corresponding natural frequencies was found with DIC. For the first time, a PVDF/CNT membrane was used for bioinspired wing fabrication, and VAT 3D printing was used to fabricate the vein structure. Results showed that integrating the nanocomposite membrane into the vein structure could yield significant improvements in structural performance in FWMAVs. This study also demonstrates the significant potential of nanocomposite membranes and additive manufacturing for fabricating bioinspired flapping wings for MAVs.