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Synthesis and Characterization of Lignin Carbon Fiber and Composites

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ABSTRACT

In this study, continuous lignin fibers from switchgrass have been successfully synthesized via multifilament melt-spinning and converted to carbon fibers using optimized stabilization and carbonization techniques. Unidirectional lignin carbon fiber reinforced composites are produced using a vacuum assisted resin transfer molding process for the first time. Produced lignin carbon fiber is evaluated in mechanical, interfacial, and microstructural areas. Single fiber mechanical properties are characterized using a unique MTS Bionix Nano-UTM. Interfacial properties and resin/fiber behavior are evaluated using single fiber fragmentation. Microstructural properties are determined using wide-angle x-ray diffraction. Mechanical results indicated an initial tensile modulus along fiber axis of 36 GPa and a failure stress of 600 MPa for single carbon fibers. Lignin carbon fibers demonstrate a nonlinear increase in modulus with applied tensile strain similar to recently observed for commercial poly-acrylonitrile (PAN) carbon fibers. Microscopy revealed few defects within and along the lignin carbon fibers, and the processed lignin fibers demonstrated minimal crystalline regions and crystallite alignment when compared to commercial PAN based fibers. Interfacial shear strength with epoxy resin was found to be 17 MPa with a fiber fracture length of 228 μm. Unidirectional composite coupons achieved tensile modulus of 9 GPa and a failure strength of 85 MPa at 1% failure strain. Lignin carbon fiber and composites produced are targeted for non-structural applications as mechanical properties are currently less than PAN carbon fibers and therefore are not suitable to replace PAN carbon fiber at this stage. Relatively low